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in
GEOGRAPHY

Semester-II

Paper: GEO205T (OC)

Self-Learning Material



DIRECTORATE OF OPEN AND DISTANCE LEARNING
UNIVERSITY OF KALYANI
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COURSE MATERIAL COMPILED BY

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Director's Message

Satisfying the varied needs of distance learners, overcoming the obstacle of distance and reaching the unreached students are the threefold functions catered by Open and Distance Learning (ODL) systems. The onus lies on writers, editors, production professionals and other personnel involved in the process to overcome the challenges inherent to curriculum design and production of relevant Self Learning Materials (SLMs). At the University of Kalyani a dedicated team under the able guidance of the Hon'ble Vice-Chancellor has invested its best efforts, professionally and in keeping with the demands of Post Graduate CBCS Programmes in Distance Mode to devise a self-sufficient curriculum for each course offered by the Directorate of Open and Distance Learning (DODL), University of Kalyani.

Development of printed SLMs for students admitted to the DODL within a limited time to cater to the academic requirements of the Course as per standards set by Distance Education Bureau of the University Grants Commission, New Delhi, India under Open and Distance Mode UGC Regulations, 2017 had been our endeavour. We are happy to have achieved our goal.

Utmost care and precision have been ensured in the development of the SLMs, making them useful to the learners, besides avoiding errors as far as practicable. Further suggestions from the stakeholders in this would be welcome.

During the production-process of the SLMs, the team continuously received positive stimulations and feedback from Professor (Dr.) Sankar Kumar Ghosh, Hon'ble Vice- Chancellor, University of Kalyani, who kindly accorded directions, encouragements and suggestions, offered constructive criticism to develop it within proper requirements. We gracefully, acknowledge his inspiration and guidance.

Sincere gratitude is due to the respective chairpersons as well as each and every member of PGBOS (DODL), University of Kalyani. Heartfelt thanks is also due to the Course Writers-faculty members at the DODL, subject-experts serving at University Post Graduate departments and also to the authors and academicians whose academic contributions have enriched the SLMs. We humbly acknowledge their valuable academic contributions. I would especially like to convey gratitude to all other University dignitaries and personnel involved either at the conceptual or operational level of the DODL of University of Kalyani.

Their persistent and co-ordinated efforts have resulted in the compilation of comprehensive, learner-friendly, flexible texts that meet the curriculum requirements of the Post Graduate Programme through Distance Mode.

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Director
Directorate of Open and Distance Learning
University of Kalyani

SYLLABUS

SEMESTER-II

[OPEN COURSE] GEO205T (OC) (TOTAL CREDIT - 4, TOTAL MARKS – 100)

GROUP – GEO205T (OC).1: EARTH AND SOCIETY

(CREDIT – 2; MARKS - 50:

INTERNAL EVALUATION – 10 + SEMESTER-END EXAMINATION - 40)

- Unit-1: Ecological system of the earth- atmosphere, lithosphere, hydrosphere and biosphere
- Unit-2: Endogenetic forces- interior of the earth and surface configuration; exogenetic forces and resultant landforms- fluvial and arid landforms
- Unit-3: Concept of land and land use; land capability classification, carrying capacity of land
- Unit-4: Measuring land surface-concept of scale and map, procedures of land survey and map making using tape and theodolite
- Unit-5: Concept of society and space, material and social space, social structure and social processes, cultural realms, cultural diffusion
- Unit-6: Rural and urban settlements and its classification
- Unit-7: Human Development Index
- Unit-8: Sustainable development

GROUP – GEO205T (OC).2: GEOGRAPHY OF RESOURCES AND HAZARDS

(Credit – 2; Marks - 50: Internal Evaluation – 10 + Semester-end Examination - 40)

- Unit-9: Concept and classification of resources, conventional and non-conventional resources
- Unit-10: Distribution of energy resources- coal
- Unit-11: Distribution of energy resources- mineral oil
- Unit-12: Crisis, conservation and management of resource
- Unit-13: Major economic activities- primary, secondary and tertiary activities
- Unit-14: Concept of hazards and disasters; Physical hazards: tropical cyclone, flood, land slide with reference to West Bengal
- Unit-15: Social hazards: poverty and crime
- Unit-16: Management of hazards and disasters

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GROUP – GEO205T (OC).1: EARTH AND SOCIETY

1.1 INTRODUCTION

In the present section the ecological system of the earth- atmosphere, lithosphere, hydrosphere and biosphere will be discussed. It discusses about the endogenetic forces and exogenetic forces and their interplay giving rise to the present configuration of the Earth's surface. It introduces the concept of land and land use; land capability classification, carrying capacity of land. It discusses the measuring land surface-concept of scale and map, procedures of land survey and map making using tape and theodolite. Concept of society and space, material and social space, social structure, social processes, cultural realms and cultural diffusion are also discussed. Rural and urban settlements and its classification, Human Development Index, Sustainable development have been discussed.

1.2 LEARNING OBJECTIVES

The present section aims to introduce the following topics:

- Ecological system of the earth- atmosphere, lithosphere, hydrosphere and biosphere
- Endogenetic forces- interior of the earth and surface configuration; exogenetic forces and resultant landforms- fluvial and arid landforms
- Concept of land and land use; land capability classification, carrying capacity of land
- Measuring land surface-concept of scale and map, procedures of land survey and map making using tape and theodolite
- Concept of society and space, material and social space, social structure and social
- processes, cultural realms, cultural diffusion
- Rural and urban settlements and its classification
- Human Development Index
- Sustainable development

1.3 ASSESSMENT OF PRIOR KNOWLEDGE

- The basic knowledge about the Earth as a part of solar system is very essential to understand the physical processes.
- A proper knowledge about the history of the Earth since 4.6 billion years through the Geological Time Scale is very important.
- Basic concept of Human geography is also important.

1.4 LEARNING ACTIVITIES

- An audio-visual teaching method using smart-classes could be helpful for the teachers to explain and students to understand the internal processes of the Earth, specially the processes of plate motion and their mechanism.
- Hands on exercise using Transit Theodolite is important.

1.5 FEEDBACK OF LEARNING ACTIVITIES

- Poster and charts regarding ecological system of the earth- atmosphere, lithosphere, hydrosphere and biosphere.
- Model on the internal structure of the Earth.

1.6 EXAMPLES AND ILLUSTRATIONS

UNIT-1

ECOLOGICAL SYSTEM OF THE EARTH- ATMOSPHERE, LITHOSPHERE, HYDROSPHERE AND BIOSPHERE

The natural systems that we study of in physical geography operate within the four great realms, or **spheres**, of the Earth. These are the atmosphere, the lithosphere, the hydrosphere, and the biosphere. The **atmosphere** is a gaseous layer that surrounds the Earth. It receives heat and moisture from the surface and redistributes them, returning some heat and all the moisture to the surface. The atmosphere also supplies carbon, hydrogen, oxygen, and nitrogen which vital elements to sustain life on Earth. The outermost solid layer of the Earth is called the **lithosphere**. The solid rock of the lithosphere bears a shallow layer of soil in which nutrient elements become available to organisms. The surface of the lithosphere is moulded into landforms. These landforms — such as mountains, hills, and plains— provide varied habitats for plants, animals, and humans. The liquid realm of the Earth is the **hydrosphere**, which is comprises the mass of water in the world's oceans. It also includes solid ice in mountain and continental glaciers. Within the atmosphere, water is present in the form of gaseous vapour, liquid droplets, and solid ice crystals. In the lithosphere, water is found in the uppermost layers in soils and in ground water reservoirs (Introducing Physical Geography - Alan H. Strahler).

The **biosphere** is an example of a system as it is composed of basically three components viz organic component, inorganic or abiotic component and energy component and these three component are mutually interdependent and interrelated through a series of large scale cyclic mechanisms which makes the input – output mechanism effective in the biosphere (Environmental Geography – Savindra Singh).

CHARACTERISTICS OF THE ATMOSPHERE

The atmosphere extends to approximately 480 kilometers (300 mi) above Earth's surface. Its density decreases rapidly with altitude; in fact, 97% of the air is concentrated in the first 25 kilometers (16 mi) or so. Because air has mass, the atmosphere exerts pressure on Earth's surface. At sea level, this pressure is about 1034 grams per square centimetre (14.7 lb/sq in.), but the higher the elevation, the lower is the atmospheric pressure.

COMPOSITION OF THE ATMOSPHERE

The atmosphere is composed of numerous gases. Most of these gases remain in the same proportions regardless of the density of the atmosphere. A bit more than 78% of the atmosphere's volume is made up of nitrogen, and nearly 21% consists of oxygen. Argon comprises most of the remaining 1%. The percentage of carbon dioxide in the atmosphere has risen through time, but is a little less than 0.04% by volume. There are traces of other gases as well: ozone, hydrogen, neon, xenon, helium, methane, nitrous oxide, krypton, and others.

Nitrogen gas (N₂) makes up the largest proportion of air. It is a very important element supporting plant growth. In addition, some of the other gases in the atmosphere are vital to the development and maintenance of life on Earth. One of the most important of the atmospheric gases is of course oxygen (O₂), which humans and all other animals use to breathe and oxidize (burn) the food that they eat. *Oxidation*, which is technically the chemical combination of oxygen with other materials to create new products, occurs in situations outside animal life as well. Rapid oxidation takes place, for instance, when we burn fossil fuels or wood and thus release large amounts of heat energy. The decay of certain rocks or organic debris and the development of rust are examples of slow oxidation. All

these processes depend on the presence of oxygen in the atmosphere. The third most abundant gas in our atmosphere is Argon (Ar). It is not a chemically active gas and therefore neither helps nor hinders life on Earth. Carbon dioxide (CO₂), the fourth most abundant gas, is involved in the system known as the *carbon cycle*. Plants, through a process known as **photosynthesis**, use carbon dioxide and water to produce carbohydrates (sugars and starches), in which amounts of energy, derived originally from the sun, are stored and used by vegetation. Oxygen is given off as a by-product. Animals then use the oxygen to oxidize the carbohydrates, releasing the stored energy. A by-product of this process in animals is the release of carbon dioxide, which completes the cycle when it is in turn used by plants in photosynthesis.

Water vapour is always mixed in some proportion with the dry air of the lower part of the atmosphere; it is the most variable of the atmospheric gases and can range from 0.02% by volume in a cold, dry climate to more than 4% in the humid tropics. Water vapour also absorbs heat in the lower atmosphere and so prevents its rapid escape from Earth. Thus, like carbon dioxide, water vapour plays a large role in the insulating action of the atmosphere. In addition to gaseous water vapour, liquid water also exists in the atmosphere as rain and as fine droplets in clouds, mist, and fog. Solid water is found in the atmosphere in the form of ice crystals, snow, sleet, and hail. Particulates are solids suspended in the atmosphere. These can be pollutants from transportation and industry, but the majority are natural particles that have always existed in our atmosphere. Particles such as dust, smoke, pollen and spores, volcanic ash, bacteria, and salts from ocean spray can all play an important role in absorption of energy and in the formation of raindrops.

SYSTEM OF LAYERING BY TEMPERATURE CHARACTERISTICS

The atmosphere can be divided into four layers according to differences in temperature and rates of temperature change. The first of these layers, lying closest to Earth's surface, is the **troposphere** which extends about 8–16 kilometers (5–10 mi) above Earth. Its thickness, which tends to vary seasonally, is least at the poles and greatest at the equator. It is within the troposphere that people live and work, plants grow, and virtually all Earth's weather and climate take place. The troposphere has two distinct characteristics that differentiate it from other layers of the atmosphere. One is that the water vapour and particulates of the atmosphere are concentrated in this one layer; they are rarely found in the atmospheric layers above the troposphere. The other characteristic of this layer is that temperature normally decreases with increased altitude. The average rate at which temperatures within the troposphere decrease with altitude is called the **normal lapse rate** (or the environmental lapse rate); it amounts to 6.5°C per 1000 meters (3.6°F/1000 ft). The altitude at which the temperature ceases to drop with increased altitude is called the *tropopause*. It is the boundary that separates the troposphere from the **stratosphere**— the second layer of the atmosphere. The temperature of the lower part of the stratosphere remains fairly constant (about 257°C, or 270°F) to an altitude of about 32 kilometers (20 mi). It is in the stratosphere that we find the ozone layer that does so much to protect life on Earth from the sun's UV radiation. As the ozone layer absorbs UV radiation, this absorbed energy results in the release of heat, and thus temperatures increase in the upper parts of the stratosphere. Some water is available in the stratosphere, but it appears as stratospheric ice clouds. These thin veils of ice clouds have no effect on weather as we experience it. Temperatures at the *stratopause* (another boundary), which is about 50 kilometers (30 mi) above Earth, are about the same as temperatures found on Earth's surface, although little of that heat can be transferred because the air is so thin. Above the stratopause is the **mesosphere**, in which temperatures tend to drop with increased altitude; the *mesopause* (the last boundary) separates the mesosphere from the

thermosphere, where temperatures increase until they approach 1100°C (2000°F) at noon. Again, the air is so thin at this altitude that there is practically a vacuum and little heat can be transferred.

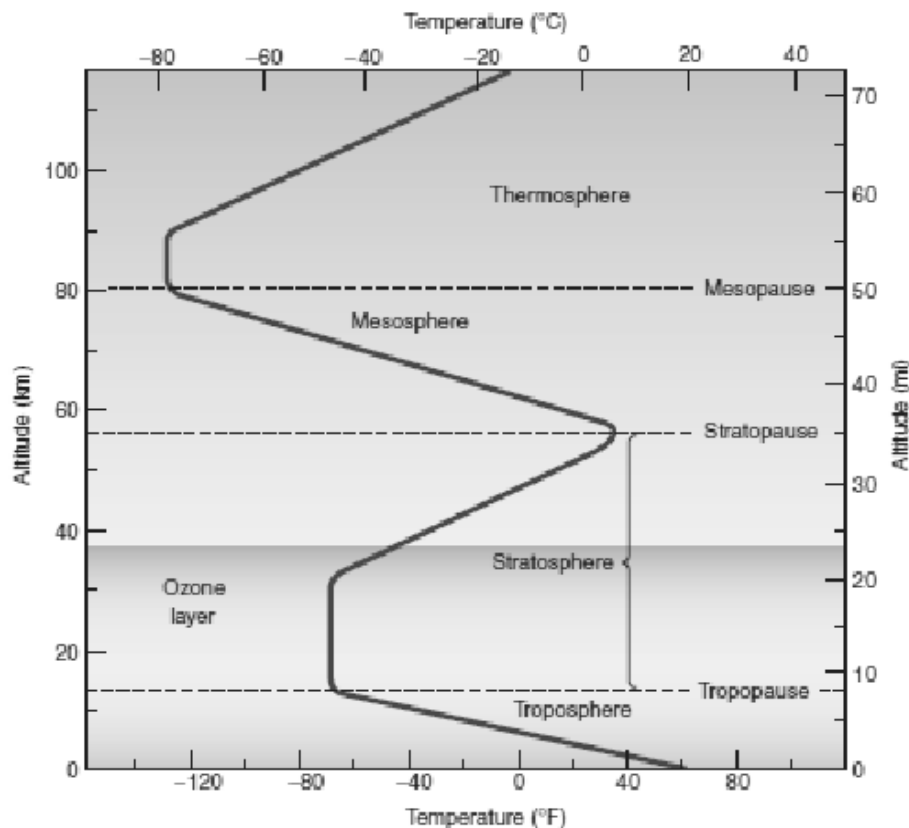


Figure 1 Vertical temperature changes in Earth's atmosphere are the basis for its subdivision into troposphere, stratosphere, mesosphere and thermosphere

System of Layering by Functional Characteristics

Astronomers, geographers, and communications experts sometimes use a different method of layering the atmosphere, one based on the protective function these layers provide. In this system, the atmosphere is divided into two distinct layers, the lowest of which is the **ozonosphere**. This layer lies approximately between 15 and 50 kilometers (10–30 mi) above the surface. The ozonosphere is another name for the ozone layer mentioned previously. Here, ozone effectively filters the UV energy from the sun and gives off heat energy instead. As we have noted, although ozone is a toxic pollutant at Earth's surface, aloft, it serves a vital function for Earth's life systems. From about 60–400 kilometers (40–250 mi) above the surface lies the layer known as the **ionosphere**. This name denotes the ionization of molecules and atoms that occurs in this layer, mostly as a result of UV rays, X-rays, and gamma radiation. (Ionization refers to the process whereby atoms are changed to ions through the removal or addition of electrons, giving them an electrical charge.) The ionosphere in turn helps shield Earth from the harmful shortwave forms of radiation. This electrically charged layer also aids

in transmitting communication and broadcast signals to distant regions of Earth. It is in the ionosphere that the auroras occur. The ionosphere gradually gives way to interplanetary space.

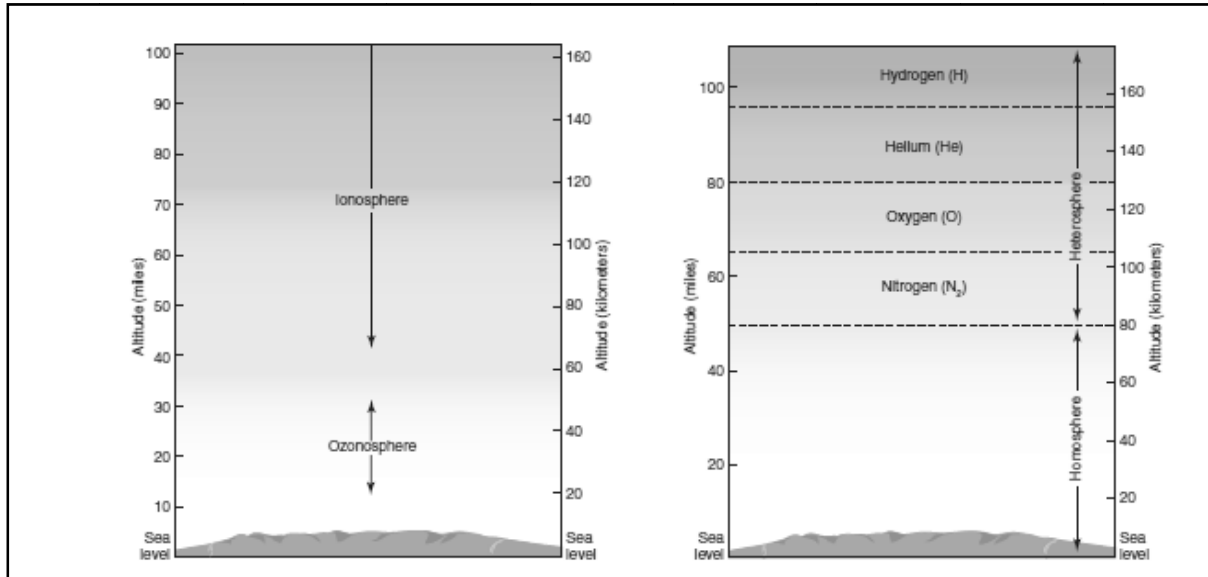


Figure 2: (Left) Vertical changes in Earth's atmosphere based on functions of the gases causes the atmosphere to be subdivided into the ozonosphere and the ionosphere.

(Right) The changes in the chemical composition of the gases allow for the subdivision of the atmosphere into homosphere and heterosphere

SYSTEM OF LAYERING BY CHEMICAL COMPOSITION

Atmospheric chemists and physicists are at times concerned with the actual chemical makeup of the atmosphere. To this end, there is one more system to divide the atmosphere into two vertical layers. The first is termed the **homosphere** (from Greek: *homo*, same throughout). This layer begins on the surface and extends to an altitude of 80 kilometers (50 mi). In this layer, the gases in our atmosphere maintain the same percent by volume. There are a few areas of concentration of specific gases, like the water vapour near Earth's surface and the ozone layer aloft, but for the most part the mixture is homogeneous. Other than rapid decreases in pressure and density while ascending through this layer, this is essentially the same air that we breathe on the surface. From an altitude of about 80 kilometers (50 mi) and reaching into the vacuum of outer space lies the **heterosphere** (from Greek: *hetero*, different). In this layer, atmospheric gases are no longer evenly mixed but begin to separate out into distinct sublayers of concentration. This separation of gases is caused by Earth's gravity in which heavier gases are pulled closer to the surface and the lighter gases drift farther outward. The regions of concentration and their corresponding gases occur in the following order: nitrogen gas (N₂) is the heaviest and therefore the lowermost, followed by atomic oxygen (O), then by helium (He), and finally atomic hydrogen (H) — the lightest element that concentrates at the outermost region.

EARTH'S PLANETARY STRUCTURE

Most of what we have learned about Earth's internal structure and composition has been deduced through indirect means. The most important evidence that scientists have used to gain such indirect knowledge is the behaviour of earthquake waves and other shock waves (generated by controlled explosions) as they pass through Earth. A sensitive instrument called a **seismograph** can record these

seismic waves, even when the earthquake is centered thousands of kilometers away or even on the opposite side of the planet. There are two major types of seismic waves, which travel at different speeds in materials of varying densities and states. These are P (primary) waves, which travel fastest and arrive first at the seismograph recording an earthquake, and S (secondary) waves, which travel more slowly. Repeated seismograph records of P and S waves suggest that these waves are refracted, or bent, as they pass through boundaries of major density change between zones within Earth's interior. The waves speed up in denser material and slow down in material that is less dense. P waves also pass through molten rock, but S waves do not. By analyzing worldwide patterns of many earthquake waves for decades, scientists have developed a general model of Earth's interior. Such information, supplemented by studies of Earth's magnetism and gravitational pull, suggests a series of layers, or zones, in Earth's internal structure. These zones, from the innermost to the surface, are known as the core, the mantle, and the crust.

EARTH'S CORE

The **core** forms one third of Earth's mass and has a radius of about 3360 kilometers (2100 mi). Earth's core is under enormous pressure—several million times atmospheric pressure at sea level (more than 100 million pounds per square inch). The core is believed to be composed primarily of iron and nickel in two distinct sections. The **outer core** is 2400 kilometers (1500 mi) thick and is made of iron and nickel. Because the outer core blocks the passage of seismic S waves that will not travel through fluids, Earth scientists assume that the outer core is molten. The **inner core** of Earth, however, appears to be solid iron. Scientists have an explanation for why it is solid. The melting point of mineral material depends not only on temperature but also on pressure. The pressure on this innermost part of Earth is so great that the inner core remains solid; that is, its melting point has been raised to a temperature above even the high temperatures found there. The outer core, though its temperatures are lower, is under less pressure and can exist in a molten state. Estimates of internal temperatures are 4800°C (8643°F) at the core–mantle boundary with an increase to 6900°C (12,423°F) at the very center of Earth. Density at the boundary between the core and the mantle is estimated at 10 grams per cubic centimeter, increasing to 13 grams per cubic centimeter at Earth's center. These high core densities contrast with the lower densities of Earth's mantle (3.3–5.5 g/cm³) and crust (2.7–3.0 g/cm³) and give our planet an average density of 5.5 grams per cubic centimeter. The high density of Earth's core is one reason that scientists believe that iron is its primary component; the density and composition of meteorites also support this theory.

EARTH'S MANTLE

The **mantle** is about 2885 kilometers (1800 mi) thick and constitutes about two thirds of Earth's mass. Earthquake waves that pass through the mantle indicate that this zone of Earth's interior is composed of dense rocky material that is solid, in contrast to the molten outer core that lies beneath it. Although most of the mantle is solid, part of the upper mantle material has the characteristics of a **plastic solid**, meaning that it can easily deform and can “flow” a few centimetres per year (an inch or two per year). Scientists agree that the mantle consists of dark, heavy silicate rocks that are high in iron and magnesium. The mantle contains several layers, or zones, of differing strength and rigidity. The uppermost layer of the mantle is solid and together with the crust forms the **lithosphere**. The term *lithosphere* has traditionally been used to describe the entire solid Earth. In recent decades, the term *lithosphere* has been used in an important and more precise way to refer to the solid outer shell of Earth, including the crust and the rigid upper mantle down to the plastic layer. Beneath the lithosphere

at a depth of about 100–700 kilometers (62–435 mi), in the upper mantle, is the **asthenosphere** (from Greek: *asthenias*, without strength), a thick layer of plastic mantle material. The material in the asthenosphere flows both vertically and horizontally, dragging segments of the overlying, rigid lithosphere along with it. Many Earth scientists now believe that the energy for tectonic forces that break and deform the crust comes from movement within the asthenosphere produced by thermal convection currents originating within the mantle and heated by decaying radioactive materials in the planet's interior. The interface between the crust and upper mantle is marked by a significant change of density, or a discontinuity, as indicated by an abrupt increase in the velocity of earthquake waves descending through this internal boundary. Scientists have labeled this zone the **Mohorovicic discontinuity**, or **Moho** for short, after the Croatian geophysicist who first detected it in 1909. The Moho does not lie at a constant depth but generally mirrors the surface topography, being deepest under mountain ranges where the crust is thick and rising to within 8 kilometers (5 mi) of the ocean floor. As of 2005, no geologic drilling has penetrated to the Moho and into the mantle. However, an international scientific partnership called the Integrated Ocean Drilling Program has come close and plans to drill to that depth in the near future.

EARTH'S CRUST

Earth's solid and rocky exterior is the *crust*, which is composed of a great variety of rocks and minerals that respond in diverse ways and at varying rates to Earth-shaping processes. The crust is the only portion of the lithosphere of which Earth scientists have direct knowledge, yet its related surface materials form only about 1% of Earth's planetary mass. Earth's crust forms the exterior of the lithosphere and is of primary importance in understanding surface processes and landforms. Earth's deep interior components, the core and mantle, are of concern to physical geography because they are responsible for and can help explain changes in the lithosphere, particularly the crust that forms the ocean floors and continents. Earth's crust is less dense than either the core or the mantle. It is also thin in comparison to the size of the planet. Two kinds of Earth crust, oceanic and continental, can be distinguished by their thickness, location, and composition. Crustal thickness varies from 3 to 5 kilometers (1.9–3 mi) in the ocean basins to as much as 70 kilometers (43 mi) under some continental mountain systems. The average thickness of continental crust is about 32–40 kilometers (20–25 mi). The crust is relatively cold, rigid, and brittle compared to the mantle. It responds to stress by fracturing, wrinkling, and raising or lowering rocks into upwarps and downwarps. **Oceanic crust** is composed of basaltic rocks, which are solidified, dark-colored, fine-grained, and iron-rich lavas. In comparison to the crust that forms the continents, oceanic crust is thinner, and because it is composed of darker, heavier, mafic rocks, it has a higher density (3.0 g/cm³). Forming the deep ocean floors, its most common minerals are compounds of silica (Si) that are relatively high in iron (Fe) and magnesium (Mg). Basalt is the most common rock on Earth and appears in great lava outflows on all of the continents as well as on the seafloor. **Continental crust** forms the major landmasses; it is much thicker, less dense (2.7 g/cm³), more sialic, and lighter in colour than oceanic crust. Although rocks of every type and of all geologic ages exist on the continents, the average density of continental crust is similar to that of granite, a common coarse-grained intrusive igneous rock. Thus, continental crust is regarded as granitic, in contrast to the basaltic oceanic crust. Granite forms from a molten state deep underground, as opposed to basalt, which cools and solidifies at the surface. Where the surface elevation is high, such as where there are mountains or plateaus, the crust is thicker; at lower elevations, continental crust is thinner, but not as thin as the crust of the seafloor.

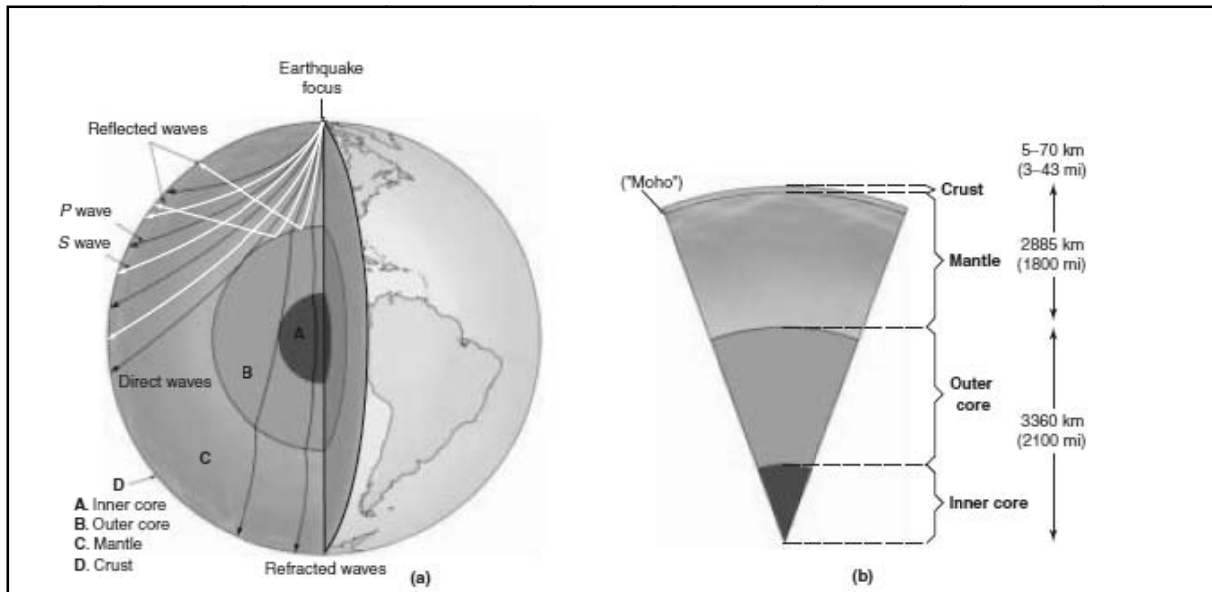


Figure 3 The internal structure of the Earth as revealed by seismic waves (a) The presence of internal changes is revealed by the refraction of P (Primary) seismic waves and the inability of S (secondary) waves to pass through Earth's liquid outer core (b) Cross section through Earth's internal structure zones.

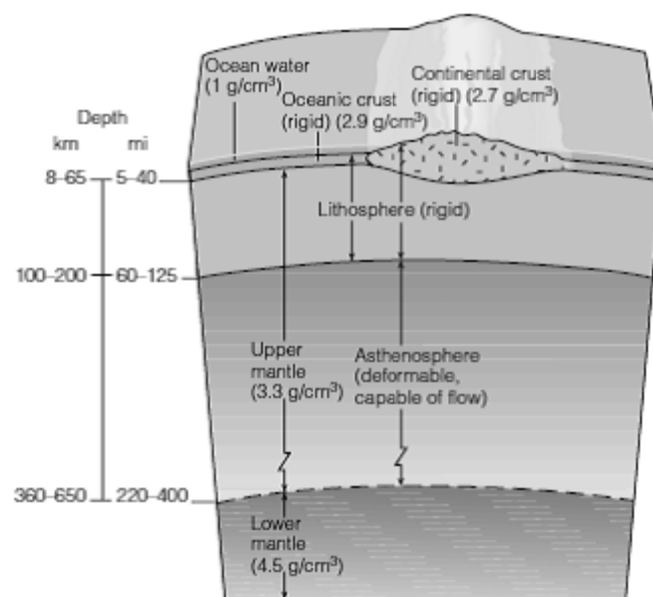


Figure 4: A cross section of the lithosphere, asthenosphere and lower mantle. The lithosphere is the solid outer part of earth including the crust and solid upper mantle, down to the asthenosphere

HYDROSPHERE

The oceans contain more than 97% of Earth's water and cover 71% of Earth's surface. The oceans actually form a single, large, continuous body of water. The "global ocean" is divided into five individual oceans that are distinguished largely on the basis of their geographic locations although they do differ somewhat in certain marine characteristics. In 2000 the International Hydrographic Organization declared that the ocean surrounding Antarctica (poleward of 60°S) should be considered a separate Southern Ocean. The rationale for this decision is based on oceanographic characteristics, particularly the Antarctic circumpolar current, which flows eastward around the continent. The five oceans are the Pacific, Atlantic, Indian, Southern, and Arctic Oceans. The approximate area of the Pacific Ocean is 156 million square kilometres (60 million sq mi). The Atlantic is about half that size, or 77 million square kilometers (30 million sq mi), and the Indian Ocean is about 69 million square kilometers (27 million sq mi). The Southern Ocean is 20 million square kilometers (8 million

sq miles), and the Arctic Ocean is 14 million square kilometres (5 million sq mi). In comparison, the continent of North America is 23 million square kilometers (9 million sq mi) in area. In fact, the total land area of Earth—149.5 million square kilometers (57.5 million sq mi)—is smaller than the Pacific Ocean, which is the Earth's largest geographic feature. The oceans also vary greatly in depth. The Pacific Ocean has an average depth of 4200 meters (13,800 ft), and the Atlantic and Indian Oceans have average depths of 3900 meters (12,800 ft). The average depth of the Southern Ocean is 4000–5000 meters (13,100–16,400 ft), and the Arctic Ocean is the shallowest averaging only 930 meters (3100 ft). However, these figures are somewhat misleading because the ocean floors are not just flat plains but have mountains, trenches, and basins that vary considerably in depth. The Pacific reaches a maximum depth of more than 11,000 meters (36,000 ft). *Seas* are saltwater bodies that are smaller than oceans and somewhat enclosed by land. Unlike lakes, which can be of either fresh water or saltwater, seas interchange water with the oceans. Examples of major seas include the Mediterranean, Baltic, Bering, Arabian, Caribbean, Coral, North, Black, Yellow, and Red Seas. Some large semi enclosed areas of the oceans are also called gulfs or bays but are actually seas as well. Examples of these include the Gulf of Mexico, Gulf of Alaska, Gulf of California, and Bay of Bengal. Large salty lakes, such as the Aral, Caspian, and Dead "Seas," are incorrectly named because they are landlocked.

CHARACTERISTICS OF OCEAN WATERS

The world ocean is 96.5% water by weight, but seawater is a dilute solution with on average 3.5%, or 35 parts per thousand (ppt), dissolved solids. Of these dissolved minerals, the most common substance by far is sodium chloride, or common table salt. Other important constituents of seawater are magnesium, sulfur, calcium, and potassium. The oceans also contain the dissolved atmospheric gases, especially oxygen and great amounts of carbon dioxide. Ocean waters contain virtually every element found on Earth. Most, however, are trace elements in concentrations of a few parts per billion (ppb). We now extract salt and magnesium from the sea, and the future extraction of other substances, including hydrogen for energy, may prove worthwhile. The measurement of all dissolved solids in seawater is referred to as **salinity**, and it varies throughout Earth's oceans and seas. Although, as already mentioned, the average salinity is 3.5% (35 ppt), this can vary in the open ocean from 3.2 to 3.8% (32–38 ppt). The salinity variation is even greater in enclosed or partially enclosed seas.

Several factors affect salinity—primarily, amounts of precipitation, inflow from rivers, and

rates of evaporation. In humid regions where precipitation is high, fresh water tends to dilute the seawater and reduce salinity. Arid and semiarid regions have a higher salinity because precipitation is low, few rivers exist, and evaporation is high. Ocean temperatures also vary and together with salinity affect density; these factors are also affected by latitudinal climate zones. Density is the mass per unit volume measured in kilograms per cubic meter (or pounds per cubic foot). The maximum density of fresh water occurs at about 4°C (39°F) and is 1000 kilograms per cubic meter (62.4 lb/cu ft). An

increase in temperature results in a decrease in density. Salinity and density are directly proportional— the greater the salinity, the denser the water. The salinity in seawater raises water density to about 1025 kilograms per cubic meter (64 lb/cu ft). Density affects circulation because density differences cause gravitational displacement of water. Warm water is less dense than cold, so it tends to float above colder, denser water. Cold or highly saline water near the surface sinks and is replaced by warmer or less saline water. These changes produce patterns of surface water movement that vary with the seasons. Density differences also cause deep-ocean currents (*thermohaline* currents) that circulate the ocean's deepest waters (Gabler, Petersen, & Tr, 2007).

UNIT-2

ENDOGENETIC FORCES- INTERIOR OF THE EARTH AND SURFACE CONFIGURATION; EXOGENETIC FORCES AND RESULTANT LANDFORMS- FLUVIAL AND ARID LANDFORMS

Our planet is almost spherical, with a radius of approximately 6400 km (about 4000 mi). Its central **core** is about 3500 km (about 2200 mi) in radius. The outer core is liquid which is inferred from measurements of earthquake waves passing through the Earth, which suddenly change behavior when they reach the core. But the innermost part of the core is solid and consists of iron, with some nickel. The temperature of the core ranges between 3000°C and 5000°C (about 5400°F to 9000°F). The core is surrounded by the **mantle**—a shell about 2900 km (about 1800 mi) thick. Temperatures in the mantle range from about 2800°C (about 5100°F) near the core to about 1800°C (about 3300°F) near the crust. The mantle is composed of *ultramafic rock*, which is made up of the densest forms of iron and magnesium combined with silicon and oxygen. The thin, outermost layer of our planet is the Earth's **crust**. This skin of varied rocks and minerals ranges from about 8 to 40 km (about 5 to 25 mi) thick and contains the continents and ocean basins. It is the source of soil on the lands, salts in the sea, gases in the atmosphere, and of all the water of the oceans, atmosphere, and lands. The base of the crust is sharply defined where it contacts the mantle. This contact is detected by the way in which earthquake waves abruptly change velocity at that level. The boundary surface between crust and mantle is called the *Moho*, after the name of the scientist, Andrija Mohorovicic, who discovered it in 1909. The crust that lies below ocean floors—*oceanic crust*—consists almost entirely of silicates of magnesium and iron—*mafic rocks*. But the *continental crust* consists of two continuous zones—an upper zone of rocks that are less dense and are composed of silicates of aluminum, sodium, potassium, and calcium *felsic rocks*—and a lower zone of denser, mafic rock. Another key distinction between continental and oceanic crust is that the crust beneath the continents is much thicker—35 km (22 mi) on average—than it is beneath the ocean floors, where it is typically 7 km (4 mi). The major relief features of the Earth—its continents and ocean basins—were created by the movements of plates on the surface of the Earth. Geologists use the term *lithosphere* to describe an outer Earth shell of rigid, brittle rock, including the crust and also the cooler, upper part of the mantle. The lithosphere ranges in thickness from 60 to 150 km (40 to 95 mi). It is thickest under the continents and thinnest under the ocean basins. Some tens of kilometres deep in the Earth, the brittle lithospheric rock gives way gradually to a plastic, or “soft,” layer named the *asthenosphere*. But at still greater depth in the mantle, the strength of the rock material increases again. Because the asthenosphere is soft and plastic, the rigid lithosphere can easily move over it. The lithospheric shell is divided into large pieces called **lithospheric plates**. A single plate can be as large as a continent and can move independently of the plates that surround it—like a great slab of ice floating on the polar sea. Lithospheric plates can separate from one another at one location, while elsewhere they may collide in crushing impacts that raise great ridges (Strahler, 2013).

SURFACE CONFIGURATIONS OF THE CONTINENTS

We divide continents into two types of region: active mountain-making belts and inactive regions of old, stable rock. The mountain ranges in the active belts grow through one of two very different geologic processes. First is *volcanism*, in which massive accumulations of volcanic rock are formed by extrusion of magma. Many lofty mountain ranges consist of chains of volcanoes built of extrusive igneous rocks. The second mountain-building process is *tectonic activity*—the breaking and bending

of the Earth's crust under internal Earth forces. This tectonic activity usually occurs when great lithospheric plates come together in titanic collisions. Crustal masses that are raised by tectonic activity create mountains and plateaus. In some instances, volcanism and tectonic activity combine to produce a mountain range. Tectonic activity can also lower crustal masses to form depressions. Active mountain-making belts are narrow zones that are usually found along the margins of lithospheric plates. We call these belts *alpine chains* because they are characterized by high, rugged mountains, such as the Alps of central Europe or the Himalayas of Asia. Even today, alpine mountain-building continues in many places. Belts of recent and active mountain-building account for only a small portion of the continental crust. The rest is much older, comparatively inactive rock. There are two types of stable structures— *continental shields* and *mountain roots*. Continental shields are regions of low-lying igneous and metamorphic rocks. Shields may be exposed or covered by layers of sedimentary rock. The core areas of some shields are made of rock dating back to the Archean eon, 2.5 to 3.5 billion years ago. Remains of older mountain belts lie within the shields in many places. These mountain roots are mostly formed of Paleozoic and early Mesozoic sedimentary rocks that have been intensely bent and folded, and in some locations changed into metamorphic rocks. Thousands of meters of overlying rocks have been removed from these old tectonic belts, so that only the lowermost structures remain. Roots appear as chains of long, narrow ridges, rarely rising over a thousand meters above sea level (Introducing Physical Geography- Alan H. Strahler).

SURFACE CONFIGURATIONS OF THE OCEAN BASINS

Oceans make up 71 percent of the Earth's surface. Relief features of oceans are quite different from those of the continents. Much of the oceanic crust is less than 60 million years old, while the great bulk of the continental crust is of Proterozoic age—mostly over 1 billion years old. The young age of the oceanic crust is quite remarkable. A *midoceanic ridge* of submarine hills divides the basin in about half. Precisely in the center of the ridge, at its highest point, is a narrow trench like feature called the *axial rift*. The location and form of this rift suggest that the crust is being pulled apart along the line of the rift. These oceans have *passive continental margins*, which haven't been subjected to strong tectonic and volcanic activity during the last 50 million years. This is because the continental and oceanic lithospheres that join at a passive continental margin are part of the same lithospheric plate and move together, away from the axial rift. But unlike the symmetrical ocean-floor model of the North Atlantic, the margins of the Pacific Ocean Basin have deep offshore oceanic trenches. We call these trenched ocean-basin edges *active continental margins*. Here, oceanic crust is being bent downward and forced under continental crust, creating trenches and inducing volcanic activity (Strahler, 2013).

EXOGENETIC FORCES AND RESULTANT LANDFORMS- FLUVIAL AND ARID LANDFORMS

FLUVIAL LANDFORMS:

STREAM EROSION

Streams erode in various ways, depending on the nature of the channel materials and the tools with which the current is armed. The flowing water drags on the bed and banks and also forces particles to hit the bed and banks. These actions easily erode alluvial materials, such as gravel, sand, silt, and clay. This form of erosion is called *hydraulic action*, and it can excavate enormous quantities in a short time when river flow is high. As the banks are undermined, large masses of alluvium slump into the river, where the particles are quickly separated and become part of the stream's load. Where rock fragments carried by the swift current strike against bedrock channel walls, they knock off chips of rock. The larger, stronger fragments become rounded as they travel. As cobbles and boulders roll over the streambed, they crush and grind the smaller grains, producing a wide assortment of grain sizes. This process of mechanical wear is called *abrasion*. In bedrock that's too strong to be eroded by

simple hydraulic action, abrasion is the main method of erosion. A striking example of abrasion is the erosion of a *pothole*. Finally, chemical weathering removes rock from the stream channel. This is called *corrosion*. We see corrosion in limestone, in particular, which develops cupped and fluted surfaces.

STREAM TRANSPORTATION

The solid matter carried by a stream is the **stream load**. Of the three forms, suspended load is generally the largest. A large river such as the Mississippi, for example, carries as much as 90 percent of its load in suspension. *Stream capacity* measures the maximum solid load of debris—including bed load and suspended load—that can be carried by a stream at a given discharge. It's given in units of tons per day passing downstream at a given location. Stream capacity increases sharply as stream velocity rises. This is because swifter currents are more turbulent, so they can hold more sediment in suspension. The capacity to move bed load also increases with velocity because faster water drags against the bed harder. In fact, the capacity to move bed load increases according to the third to fourth power of the velocity. In other words, if a stream's velocity is doubled in times of flood, its ability to transport bed load will increase from 8 to 16 times. So, most of the conspicuous changes in a stream channel occur in a flood. When waterflow increases, a stream flowing in a silt, sand, or gravel channel will easily widen and deepen that channel. When the flow slackens, the stream will deposit material in the bed, filling the channel again. If the stream flows in a hard bedrock channel, it won't be able to deepen the channel as quickly in response to rising waters, so it may not change much during a single flood. Such conditions exist in streams in deep canyons with steep gradients.

STREAM GRADATION

Most major stream systems have gone through thousands of years of runoff, erosion, and deposition. Over time, the gradients of different parts of the stream adjust so that they just carry the average load of sediment that they receive from slopes and inflowing channels.

A stream in this condition is called a **graded stream**. How does this come about?

FLUVIAL LANDSCAPES

WATERFALLS

Large *waterfalls* are comparatively rare the world over, since the stream gradation process drains lakes and removes falls and rapids. But when tectonic activity fractures and dislocates crustal blocks, erosion may be hard pressed to keep up. As a result, we see great waterfalls on several large rivers in the African Rift Valley region.

AGGRADATION AND ALLUVIAL TERRACES

Graded streams are delicately adjusted to their supply of water and rock waste from upstream sources. So they are highly sensitive to any changes in those inputs. Changes in climate or vegetation cover affect the discharge and stream load at downstream points, and these changes in turn require channel readjustments. One such change is the build up of alluvium in valley floors.

ALLUVIAL RIVERS AND THEIR FLOODPLAINS

Now let's examine the floodplain of a graded river. As time passes, the floodplain is widened, so that broad areas of floodplain lie on both sides of the river channel. Civil engineers have given the name **alluvial river** to a large river of very low channel gradient. It flows on a thick floodplain of alluvium constructed by the river itself in earlier stages of its activity. An alluvial river in a humid environment

normally experiences overbank floods each year or two. Bluffs are cut when meanders excavate older terraces or pre-existing materials. Ox-bow lakes remain when meanders are cut off. When the floodplain is inundated, sand and silt are deposited in a zone next to the channel, creating *natural levees*. These flanks of high ground along the channel are normally the sites of towns and villages. Between the levees and the bluffs is lower ground, called the backswamp, which is subject to frequent flooding. It is best suited to agriculture, as regular overbank flooding of the backswamp provides a new layer of silt and infuses the soil with dissolved minerals. The resupply of nutrients helps floodplain soils retain their remarkable fertility, even though they may be located in regions of rainfall surplus from which these nutrients are normally leached away.

ENTRENCHED MEANDERS

What happens when a broadly meandering river is uplifted by rapid tectonic activity? The uplift increases the river's gradient, and in turn, its velocity, so that it cuts downward into the bedrock below. This forms a steep-walled *inner gorge*. On either side of the gorge there will be the former floodplain, now a flat terrace high above river level. Any river deposits left on the terrace are rapidly stripped off by runoff because floods no longer reach the terraces to restore eroded sediment. The meanders become impressed into the bedrock, passing on their meandering pattern to the inner gorge. We call these sinuous bends *entrenched meanders* to distinguish them from the floodplain meanders of an alluvial river. Although entrenched meanders are not free to shift about as floodplain meanders do, they can slowly enlarge, producing cut-offs that can leave a high, round hill separated from the valley wall by the deep abandoned river channel and the shortened river course. As you might guess, such hills formed ideal natural fortifications. Many European fortresses of the Middle Ages were built on such cut-off meander spurs. Occasionally, if the bedrock includes a strong, massive sandstone formation, the meander cut-off can leave a *natural bridge* formed by the narrow meander neck.

FLUVIAL PROCESSES IN AN ARID CLIMATE

Desert regions look strikingly different from humid regions in both vegetation and landforms. Obviously, the lower precipitation makes the difference. Vegetation is sparse or absent, and land surfaces are mantled with mineral material—sand, gravel, rock fragments, or bedrock itself. Although deserts have low precipitation, rain falls in dry climates as well as in moist, and most landforms of desert regions are formed by running water. A particular locality in a dry desert may experience heavy rain only once in several years. But when rain does fall, stream channels carry water and perform important work as agents of erosion, transportation, and deposition. Fluvial processes are especially effective in shaping desert landforms because of the sparse vegetation cover. The few small plants that survive offer little or no protection to soil or bedrock. Without a thick vegetative cover to protect the ground and hold back the swift downslope flow of water, large quantities of coarse rock debris are swept into the streams. A dry channel is transformed in a few minutes into a *flash flood* of muddy water heavily charged with rock fragments. Water enters and leaves a stream channel differently in arid climates than in humid climates. In a humid region, the high water table slopes toward a stream channel, and ground water seeps into the streambed, producing permanent (perennial) streams. In arid regions, the water table lies far below the channel floor. Where a stream flows across a plain of gravel and sand, water is lost from the channel by seepage. As a result, aggradation occurs and braided channels are common. Streams of desert regions are often short and end in alluvial deposits or on the floors of shallow, dry lakes.

ALLUVIAL FANS

One very common landform built by braided, aggrading streams is the **alluvial fan**. This is a low cone of alluvial sands and gravels resembling an open fan. The central point of the fan lies at the mouth of a canyon or ravine. The fan is built out on an adjacent plain. Alluvial fans are of many sizes. Some desert fans are many kilometers across. Fans are built by streams carrying heavy loads of coarse rock

waste from a mountain or an upland region. The braided channel shifts constantly, but its position is firmly fixed at the canyon mouth. The lower part of the channel, below the apex, sweeps back and forth—accounting for the fan form and the downward slope in all radial directions away from the apex. Alluvial fans are primary sites of ground water reservoirs in the southwestern United States. In many fan areas, we have rapidly lowered the water table by pumping for irrigation. It will take an extremely long time to recharge these ground water reserves from precipitation. One serious side effect of removing too much ground water is subsidence.

ARID LANDFORMS:

THE LANDSCAPE OF MOUNTAINOUS DESERTS

Where tectonic activity has recently produced block faulting in an area of continental desert, the assemblage of fluvial landforms is particularly diverse and interesting. The basin-and-range region of the western United States, which includes large parts of Nevada and Utah, southeastern California, southern Arizona, and New Mexico, is an example. The initial uplift creates two uplifted fault blocks with a down dropped block between them. Although denudation acts on the uplifted blocks as they are being raised, we have shown them as very little modified at the time tectonic activity has ceased. At first, the faces of the fault block are extremely steep. They are scored with deep ravines, and talus blocks form cones at the bases of the blocks. At a later stage of erosion, streams have carved the mountain blocks into a rugged landscape of deep canyons and high divides. Rock waste from these steep mountain slopes is carried from the mouths of canyons to form large alluvial fans. The fan deposits form a continuous apron extending far out into the basins. In the center of the desert basin is a dry lakebed, or **playa**, where fine sediments and precipitated salts produce a flat basin floor. In some playas, shallow water forms a salt lake. A gently sloping rock surface, thinly veneered with alluvium, sometimes stretches from the mountain flank toward the playa. This surface a *pediment*—may be an ancient low-angle fault plane; an old surface created by many years of weathering during a wetter climate; or a surface formed by retreat of the mountain front.

WIND ACTION

Wind plays a direct role in shaping coastal landforms, carrying sand and other sediments, and depositing them at new locations. We use the term *eolian*, which comes from “Aeolus,” the name of the Greek god of the winds, to describe wind-generated landforms and processes. Dunes are thus *eolian landforms*. Ordinarily, wind isn’t strong enough to dislodge mineral matter from the surfaces of unweathered rock, from moist, clay-rich soils, or from soils bound by a dense plant cover. Normal winds only erode and transport sediment on land surfaces where small mineral and organic particles are in a loose, dry state—typically, deserts and semiarid lands (steppes). In coastal environments, beaches can also provide a supply of loose sand to be shaped. Here the wind builds coastal dunes, even where the climate is humid and the land surface inland from the coast is well protected by a plant cover.

EROSION BY WIND

Wind performs two kinds of erosional work: abrasion and deflation. Loose particles lying on the ground surface may be lifted into the air or rolled along the ground by wind action. In the process of *wind abrasion*, wind drives mineral particles against an exposed rock or soil surface, wearing down the surface. The sandblasting action of wind abrasion is usually limited to the bottom meter or two of exposed rock above a flat plain. That’s because sand grains don’t rise much higher into the air. Wind abrasion produces pits, grooves, and hollows in the rock. You’ll often see that wooden utility poles on windswept plains have a protective

metal sheathing or a heap of large stones placed around the base. Without this protection, they would quickly be cut through at the base.

DEFLATION

Deflation is the removal of loose particles from the ground by wind. Deflation acts on loose soil or sediment, and so dry river courses, beaches, and areas of recently formed glacial deposits are susceptible. In dry climates, much of the ground surface can be deflated because the soil or rock is largely bare of vegetation. The finest particles, those of clay and silt sizes, are lifted and raised into the air—sometimes to a height of a thousand meters (about 3300 ft) or more. Sand grains are moved by moderately strong winds and usually travel within a meter or two (about 3 to 6 ft) of the ground. Gravel fragments and rounded pebbles can be rolled or pushed over flat ground by strong winds, but they don't travel far. They become easily lodged in hollows or between other large particles. If there's a mixture of particles of different sizes on the ground, deflation removes the finer sized particles and leaves the coarser particles behind. A **blowout** is a shallow depression produced by deflation. The size of the depression may range from a few meters (10 to 20 ft) to a kilometre (0.6 mi) or more in diameter, although it is usually only a few meters deep. Blowouts form in plains regions of dry climate. Any small depression in the surface of the plain, especially where the grass cover has been broken or disturbed, can form a blowout. Rains fill the depression and create a shallow pond or lake. As the water evaporates, the mud bottom dries out and cracks, leaving small scales or pellets of dried mud. These particles are lifted out by the wind. Deflation is also active in semidesert and desert regions. In the southwestern United States, playas often occupy large areas. Deflation has reduced many of these playas by several meters. Rain beating down on the ground, overland flow, and deflation may be active for a long period on the gently sloping surface of a desert alluvial fan or alluvial terrace. These processes remove fine particles, leaving coarser, heavier materials behind. As a result, rock fragments ranging in size from pebbles to small boulders become concentrated into a surface layer known as a **desert pavement**. The large fragments become closely fitted together, concealing the smaller particles—grains of sand, silt, and clay—that remain beneath. The pavement acts as armour that protects the finer particles from rapid removal by deflation. However, the pavement is easily disturbed by wheeled or tracked vehicles, exposing the finer particles and allowing severe deflation and water erosion to follow.

SAND DUNES AND LOESS

A **sand dune** is any hill of loose sand shaped by the wind. Sand dunes form where there is a source of sand—for example, a sandstone formation that weathers easily to release individual grains, or perhaps a beach supplied with abundant sand from a nearby river mouth. Active dunes constantly change shape under wind currents, but they must be free of a vegetation cover in order to form and move. They become inactive when stabilized by a vegetation cover, or when patterns of wind or sand sources change. Dune sand is usually composed of quartz, which is extremely hard and doesn't easily decay. Dune sand grains are beautifully rounded by abrasion. In strong winds, sand grains move downwind in long, low leaps, bouncing after impact with other grains. This type of hopping, bouncing movement is called *saltation*.

TYPES OF SAND DUNES

One common type of sand dune is an isolated dune of free sand called a *barchan*, or *crescent dune*. This type of dune has the outline of a crescent, and the points of the crescent are directed downwind. Barchan dunes usually rest on a flat, pebble-covered ground surface. They begin as a sand drift in the lee of some obstacle, such as a small hill, rock, or clump of brush. Once a sufficient mass of sand has gathered, it begins to move downwind, becoming a crescent. We usually find barchan dunes arranged in chains extending downwind from the sand source. *Transverse dunes* are formed when there is so

much sand that it completely covers the solid ground. These dunes are wave-like ridges separated by trough-like furrows. They are called transverse dunes because their crests are at right angles to the wind direction, much like waves on an ocean. The entire area is known as a *sand sea* because it resembles a storm-tossed sea that is suddenly frozen in motion. In the Sahara Desert, enormous quantities of reddish dune sand have been weathered from sandstone. This sand makes up a great sand sea, called an *erg*. Elsewhere, you find a desert pavement of pebbles on top of vast flat-surfaced sheets of sand. This type of surface is called a *reg*. Saharan dunes can be elaborately shaped. For example, Arabian *star dunes* have served for centuries as reliable landmarks for desert travelers because they remain fixed in place. You can also see star dunes in the deserts of the border region between the United States and Mexico. *Parabolic dunes* have the opposite curvature, with respect to wind direction, as the barchan dune. A common type of parabolic dune is the *coastal blowout dune*. These dunes form along shorelines where sand is abundant. On semiarid plains, where vegetation is sparse and winds are strong, groups of parabolic blowout dunes develop to the lee of shallow deflation hollows. Sand is caught by low bushes and accumulates on a broad, low ridge. These dunes have no steep slip faces and may remain relatively immobile. In some cases, the dune ridge migrates downwind, forming *hairpin dunes* with long parallel sides. Another class of dunes consists of long, narrow ridges oriented parallel with the direction of the prevailing wind. These *longitudinal dunes* may be many kilometers long and cover vast areas of tropical and subtropical deserts in Africa and Australia. In the United States, longitudinal and parabolic dunes occur on the Colorado Plateau, near the adjacent northern corners of Arizona and New Mexico.

COASTAL FOREDUNES

Landward of beaches, there is often a narrow belt of dunes guarding the coastline. These *coastal foredunes* are irregularly shaped hills and depressions. They are normally covered by beach grass with a few other species of plants that can survive the severe environment. This plant cover traps sand moving landward from the adjacent beach. As a result, the foredune ridge builds upward, becoming a barrier several meters above high-tide level. Foredunes form a protective barrier for tidal lands on the landward side of a beach ridge or barrier island. In a severe storm, the swash of storm waves cuts away the upper part of the beach. Although the foredune barrier may then be attacked by wave action and partly cut away, it will not usually yield. Between storms, the beach is rebuilt, and, in due time, wind action restores the dune ridge, if plants are maintained. But if the plant cover of the dune ridge is trampled and reduced by traffic—from vehicles or by foot—deflation will rapidly create a blowout. The new cavity becomes a trench across the dune ridge. When storms bring high water levels and intense wave action, swash is funneled through the gap and spreads out on the tidal marsh or tidal lagoon behind the ridge. Sand swept through the gap is spread over the tidal deposits. If eroded, the gap can become a new tidal inlet for ocean water to reach the bay beyond the beach. For many coastal communities of the eastern U.S. seaboard, dune ridges protect tidal marshes and estuaries from overwash.

LOESS

In several large midlatitude areas of the world, the surface is covered by deposits of wind-transported silt that have settled out from dust storms over thousands of years. This material is known as **loess**. (The pronunciation of this German word is somewhere between “lerse” and “luss.”) Loess is usually a uniform yellowish to buff colour and lacks any visible layering. It tends to break away along vertical cliffs wherever it is exposed by the cutting of a stream or grading of a roadway. It is also very easily eroded by running water, and when the vegetation cover that protects it is broken, it is rapidly carved into gullies. Loess has been widely used for cave dwellings both in China and in Central Europe because it’s easily excavated. The thickest deposits of loess are in northern China, where layers over

30 m (about 100 ft) thick are common and a maximum thickness of 100 m (about 300 ft) has been measured. This layer covers many hundreds of square kilometers and appears to have been brought as dust from the interior of Asia. In the United States, there are thick loess deposits in the Missouri-Mississippi Valley. The American and European loess deposits are directly related to the continental glaciers of the Ice Age. At the time when the ice covered much of North America and Europe, the winter climate was generally dry in the land bordering the ice sheets. Strong winds blew southward and eastward over the bare ground, picking up silt from the floodplains of braided streams that discharged the meltwater from the ice. This dust settled on the ground between streams, gradually building up a smooth, level ground surface. The loess is particularly thick along the eastern sides of the valleys because of prevailing westerly winds. It is well exposed along the bluffs of most streams flowing through these regions today. Loess is an important agricultural resource. It forms rich black soils that are especially suited to cultivation of grains. The highly productive plains of southern Russia, the Argentine pampa, and the rich grain region of north China are underlain by loess. In the United States, corn is extensively cultivated on the loess plains in Kansas, Iowa, and Illinois. Wheat is grown farther west on the loess plains of Kansas and Nebraska and in the Palouse region of eastern Washington.

INDUCED DEFLATION

Induced deflation is a frequent occurrence when shortgrass prairie in a semiarid region is cultivated without irrigation. Plowing disturbs the natural soil surface and grass cover, and in drought years, when vegetation dies out, the unprotected soil is easily eroded by wind action. That's why much of the Great Plains region of the United States has suffered from dust storms generated by turbulent winds. Strong cold fronts frequently sweep over this area and lift dust high into the atmosphere at times when soil moisture is low. The "Dust Bowl" of the

1930s resulted from induced deflation. Human activities in very dry, hot deserts have also significantly helped raise high dust clouds. As grazing animals and humans trample the fine-textured soils of the desert of northwest India and Pakistan (the Thar Desert bordering the Indus River), they produce a dust cloud. Such clouds hang over the region for long periods and can extend to heights of 9 km (Strahler, 2013).

UNIT-3

CONCEPT OF LAND AND LAND USE; LAND CAPABILITY CLASSIFICATION, CARRYING CAPACITY OF LAND

The classification of land according to its quality for a particular purpose is known as land classification.

In general, land use classification has two components, as under:

- I. The assessment of physical quality and agricultural potentiality. This is also known as 'land capability'. The physical properties of land are almost unchangeable. In fact, the character and quality of land and its soil depend on the parent material, temperature, rainfall, water retaining capacity, soil texture, soil structure and humus contents. These properties of land do not change over shorter period of time.
2. The assessment of land quality under the prevailing set of socioeconomic circumstances including farm structure, availability of irrigation, relative cost of labour, capital inputs, level of technology and price stability. The economic and social controls on production are more variable.

A number of land use classification systems are in vogue in different countries of the world. The first systematic land classification was done by L.D. Stamp. In his land classification of Britain, Stamp adopted a seven-fold system, i.e., (i) arable, (ii) heath and rough, (iii) pastures, (iv) orchards and nurseries, (v) meadowland, (vi) forest and woodland, and (vii) urban areas. The details and justification of this classification have been explained in Stamp's monumental work: *Land of Britain: Its Use and Misuse*. This classification helped overcoming many of the problems pertaining to the demand of land after the Second World War. Subsequently, Coleman, a student Stamp, adopted a classification of 13 major classes with various divisions, making 70 land use types in all. The International geographical Union (IGU) resolved to produce a unified classification system for the whole world but in the absence of adequate and able data, particularly about the developing countries, it could not become possible. Subsequently, Jones, Finch (1925) stressed on the importance of land use classification for planning and development. In 1925, Whittlesey took into consideration several socioeconomic indicators for the delineation of agricultural typologies of the world. Looking at the arduous and cumbersome nature of the task of land use survey and land use classification, the American geographers gave emphasis on sampling techniques. The sampling techniques were considered superior to field survey as they economize on time, effort and money. In India, M. Shafi is the pioneer of land use studies. He published the *Land Use Survey in Eastern Uttar Pradesh* in 1962. Under his supervision over two dozen students completed their doctoral theses in the field of agricultural land use studies. The availability of satellite imageries has revolutionized the whole technique of land use classification. The main weakness of the traditional land use survey is that it gives only a static description of existing land use and is very time, effort and costly.

LAND SUITABILITY SURVEY

Land classification, on the basis of land capability, has been considered as a more important document for the planning and development of agriculture. Land capability classification is a scientific appraisal of the physical characteristics of land, its inherent soil qualities, and the farm management practices. The land capability maps are more useful for the delineation of problematic and potential arable lands.

In several developed countries land has been classified on the basis of land capability, suitability, agricultural productivity and land irrigation. Stamp, in 1960, introduced the concept of

potential production unit (PPU) as a standard unit for land classification. A PPU may be defined as the potential production of one acre of good average farm land under good farm management practices. A rough scale of PPU was developed as under:

One acre of class I = 2.00 PPU

One acre of class II = 1.00 PPU

One acre of class III = 0.50 PPU

By applying the PPU technique for land classification one may assess the loss of cultivated land if that is devoted to some other uses (e.g. industries, housing, etc.). For example, if 100 acres of class II (medium quality) of land are used for the construction of a factory, it will be a loss of 100 PPU, while if the class I (good quality) land used for establishment of that factory the loss will be equivalent 200 PPU, and by constructing the factory in the class III category (poor quality), the loss will be to the extent of only 50 PPU. It will, therefore, be more judicious and rational to construct the factory on the poor quality of land where the loss of potential production units is the minimum. Thus, the potential production unit is a good technique for the delineation of land capability regions.

LAND CAPABILITY

Land capability is one aspect of land classification. For the determination of land capability, the usefulness of land for agriculture, forest and tourism is assessed solely on the basis of physical environmental factors. In other words, in land capability classification, the texture, structure of soil, aspect of slope, terrain, temperature, rainfall, runoff and water availability are taken into consideration. This method classification, however, depends on soil survey. Moreover, the present farm productivity or actual land use are ignored.

As a matter of fact, the loamy soil differs from the *regur* (black earth) soil and the lateritic soil is different from the red soil. These soils are suitable for the cultivation of different crops. For example, loamy soil is ideally suited for the cultivation of rice, wheat, sugarcane, jute, pulses, gram and oilseeds, while cotton performs well in black earth soil. The cultivation of saffron is possible only in the *karewa* lands, while *bajra* (*bulrush* millet) grow well in the sandy soil. Thus, the land capability of a soil has certain physical properties which help in getting better agricultural returns of certain crops.

The assessment system devised by the Commonwealth Scientific and Industrial Research Organization (CSIRO) for use in Australia has been widely used elsewhere. Land capability is usually presented cartographically either by type of terrain or by some judgement of potential agricultural productivity. Limited attempts have been made to produce land capability assessment for recreational land use.

In India, the primary aim of soil survey was to achieve land capability classification. The All India Soil and Land Use Survey Organization, in 1960, has attempted such a classification. Subsequently, inadequacies in the Soil Survey Manual were removed and the revised Manual was published in 1970. The All India Soil and Land Use Survey Organization (1970) has identified eight different land use capability classes as given below:

LAND SUITABLE FOR CULTIVATION

Class I: Very good cultivable land with no specific difficulty in farming.

Class II: Good cultivable land which needs protection from erosion or floods, drainage improvement and conservation of irrigation water.

- Class III: Moderately good cultivable land where special attention has to be paid to erosional control, conservation of irrigation water, intensive drainage and protection from floods.
- Class IV: Fairly good land suited for occasional or limited cultivation, needs intensive erosional control, intensive drainage and very intensive treatment to overcome soil limitations.

LAND NOT SUITABLE FOR CULTIVATION

- Class V: Very well suited for grazing but not for arable farming, needs protection from gullyng.
- Class VI: Well suited for grazing or forestry but not for arable farming.
- Class VII: Fairly well suited for grazing or forestry but not for arable farming. class VIII: Suited only for wildlife, recreational facilities and protection of water supplies (Majid, 2005).

UNIT-4

MEASURING LAND SURFACE-CONCEPT OF SCALE AND MAP, PROCEDURES OF LAND SURVEY AND MAP MAKING USING TAPE AND THEODOLITE

All globes and maps depict the Earth's features in much smaller size than the true features they represent. Globes are intended in principle to be perfect scale models of the Earth itself, differing from the Earth only in size. The scale of a globe is the ratio between the size of the globe and the size of the Earth, where "size" is some measure of length or distance (but not of area or volume). Take, for example, a globe 20 cm (about 8 in.) in diameter, representing the Earth, which has a diameter of about 13,000 km. The scale of the globe is the ratio between 20 cm and 13,000 km. Dividing 13,000 by 20, we see that one centimetre on the globe represents 650 kilometres on the Earth. This relationship holds true for distances between any two points on the globe. Scale is often stated as a simple fraction, termed the **scale fraction**. It can be obtained by reducing both Earth and globe distances to the same unit of measure, which in this case is centimetres. (There are 100,000 centimetres in one kilometre.) The advantage of the scale fraction is that it is entirely free of any specified units of measure, such as the foot, mile, meter, or kilometre. It is usually written as a fraction with a numerator of one using either a colon or with the numerator above the denominator. For the example shown above, the scale fraction is obtained by reducing 20/1300000000 to 1/65000000 or 1:65,000,000. In contrast to a globe, a flat map cannot have a constant scale. However, it is usually possible to select a meridian or parallel—the equator, for example—for which a scale fraction can be given, relating the map to the globe it represents (Strahler, 2013).

SMALL-SCALE AND LARGE-SCALE MAPS

When geographers refer to small-scale and large-scale maps, they mean the value of the scale fraction. For example, a global map at a scale of 1:65,000,000 has a scale fraction value of 0.0000001534, which is obtained by dividing 1 by 65,000,000. A hiker's topographic map might have a scale of 1:25,000, for a scale value of 0.000040. Since the global-scale value is smaller, it is a *small-scale map*, while the hiker's map is a *large-scale map*. Note that this contrasts with common use of the terms *large-scale* and *small-scale*. When we refer in conversation to a large-scale phenomenon or effect, we typically refer to something that takes place over a large area and that is usually best presented on a small-scale map. Maps of large scale show only small sections of the Earth's surface. Because they "zoom in," they are capable of carrying an enormous amount of geographic information in a convenient and an effective manner. Most large-scale maps carry a graphic scale, which is a line marked off into units representing kilometers or miles. Graphic scales make it easy to measure ground distances. For practical reasons, maps are printed on sheets of paper usually less than a meter (3 ft) wide, as in the case of the ordinary highway map or navigation chart. Bound books of maps—atlases, that is—usually have pages no larger than 30 by 40 cm (about 12 by 16 in.), whereas maps found in textbooks and scientific journals are even smaller (Strahler, 2013).

MAPS THAT PRESERVE SHAPE

On a conformal projection, all local angles measured from a point are correct and all local shapes are true. You should use a conformal projection when the map's main purpose involves measuring angles, showing accurate local directions, or representing the shapes of features or contour lines. This category includes:

- Topographic maps and cadastral (land parcel) maps
- Navigation charts (for plotting course bearings and wind direction)
- Civil engineering maps
- Military maps
- Weather maps (for showing the local direction in which weather systems are moving)

Most of the maps in the list above would be large or medium-scale. In fact, most large-scale maps nowadays are conformal, regardless of their purpose. At large scales, a conformal projection centered on the area of interest produces insignificant errors in distance and area. "Large-scale" is not an exact term, but in this context means scales of 1:100,000 or larger. It may also apply to smaller scales if the area of interest has a compact shape.

AREA

If a map preserves area, then the size of a feature on a map is the same relative to its size on the earth. For example, on an equal-area world map, Norway takes up the same percentage of map space that it actually takes up on the earth. To look at it another way, a coin moved to different spots on an equal-area map represents the same amount of actual ground no matter where you put it.

In an equal-area map, the shapes of most features are distorted. No map can preserve both shape and area for the whole world, although some come close over sizeable regions.

MAPS THAT PRESERVE AREA

On an equal-area projection, the size of any area on the map is in true proportion to its size on the earth. You should use equal-area projections to show:

- The density of an attribute with dots (for example, population density)
- The spatial extent of a categorical attribute (for example, land use maps)
- Quantitative attributes by area (for example, gross domestic product by country)

Equal-area maps have also been used as world political maps to correct popular misconceptions about the relative sizes of countries. If areas are not in true proportion, the map will give false impressions about how the population is distributed. For example, in a dot-density map of world population where one dot represents one million people, countries that draw larger than their true area scale will look

less dense than they should, while countries that draw smaller than their true area scale will look too dense.

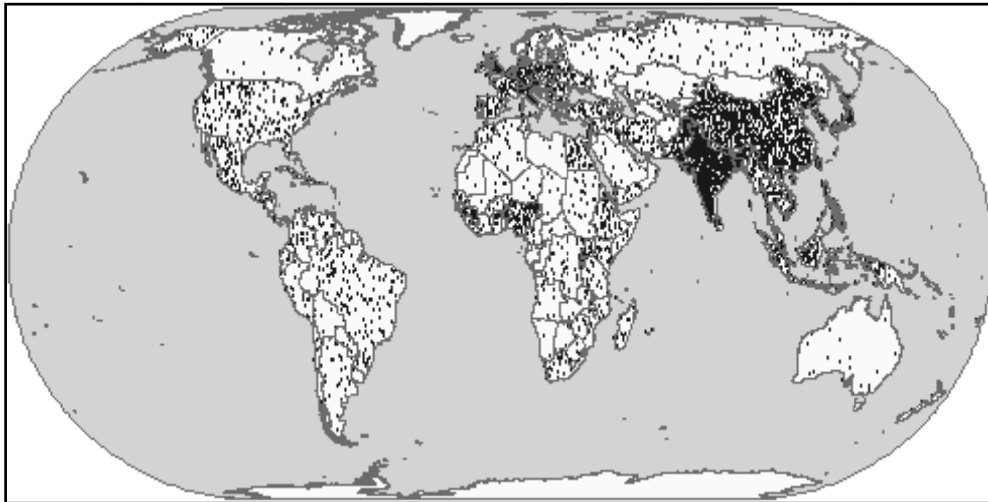


Figure 5: The Eckert IV equal-area projection applied here is used by the National Geographic Atlas, 7th edition, for several of its world thematic maps.

DISTANCE

If a line from a to b on a map is the same distance (accounting for scale) that it is on the earth, then the map line has true scale. No map has true scale everywhere, but most maps have at least one or two lines of true scale.

An equidistant map is one that preserves true scale for all straight lines passing through a single, specified point. For example, in an equidistant map centered on Geneva, Switzerland, a linear measurement from Geneva to any other point on the map would be correct.

MAPS THAT PRESERVE SCALE (DISTANCE)

No map provides true-to-scale distances for every measurement you might make. The Azimuthal Equidistant projection preserves true scale from a single specified point on the projection to all other points on the map.

Possible applications include:

- Maps of airline distances from a single city to several other cities
- Seismic maps showing distances from the epicenter of an earthquake
- Maps used to calculate costs or charges based on straight-line distances from a source
- Maps used to calculate ranges; for example, the cruising ranges of airplanes or the habitats of animal species

The Two-Point Equidistant projection preserves true scale from two specified points on the projection to all other points on the map. This projection could be used to determine the distance of a ship at sea from the start and end of its voyage.

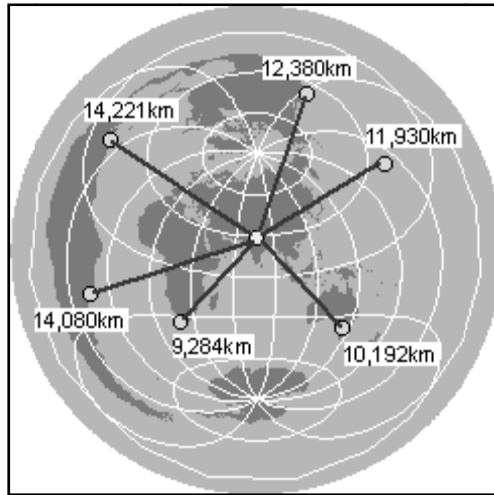


Figure 6: An Azimuthal Equidistant projection centered on New Delhi. Scale from New Delhi to all points (and likewise from all points to New Delhi) is correct.

DIRECTION

Direction, or azimuth, is measured in degrees of angle from north. On the earth, this means that the direction from a to b is the angle between the meridian on which a lies and the great circle arc connecting a to b.

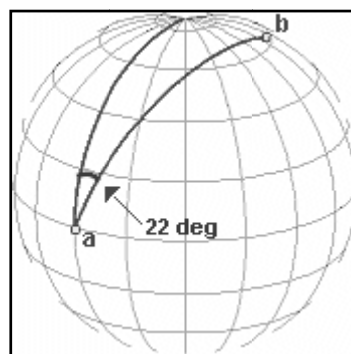


Figure 7: The azimuth of a to b is 22 degrees.

If the azimuth value from a to b is the same on a map as on the earth, then the map preserves direction from a to b. An azimuthal projection is one that preserves direction for all straight lines passing through a single, specified point. No map has true direction everywhere. Remember, if a map preserves two spatial properties, one of them is always true direction.

MAPS THAT PRESERVE DIRECTION

On any azimuthal projection, all azimuths, or directions, are true from a single specified point to all other points on the map. (On a conformal projection, directions are locally true, but are distorted with distance.) Direction is not typically preserved for its own sake, but in conjunction with another property.

In navigation and route planning, however, direction matters for its own sake. The Gnomonic projection is unique among azimuthal projections in that every straight line drawn on it represents the

arc of a great circle. Because a great circle is the shortest distance between two points, Gnomonic projections are useful for planning air and sea routes and for mapping phenomena, like radio waves, that follow shortest-distance paths.

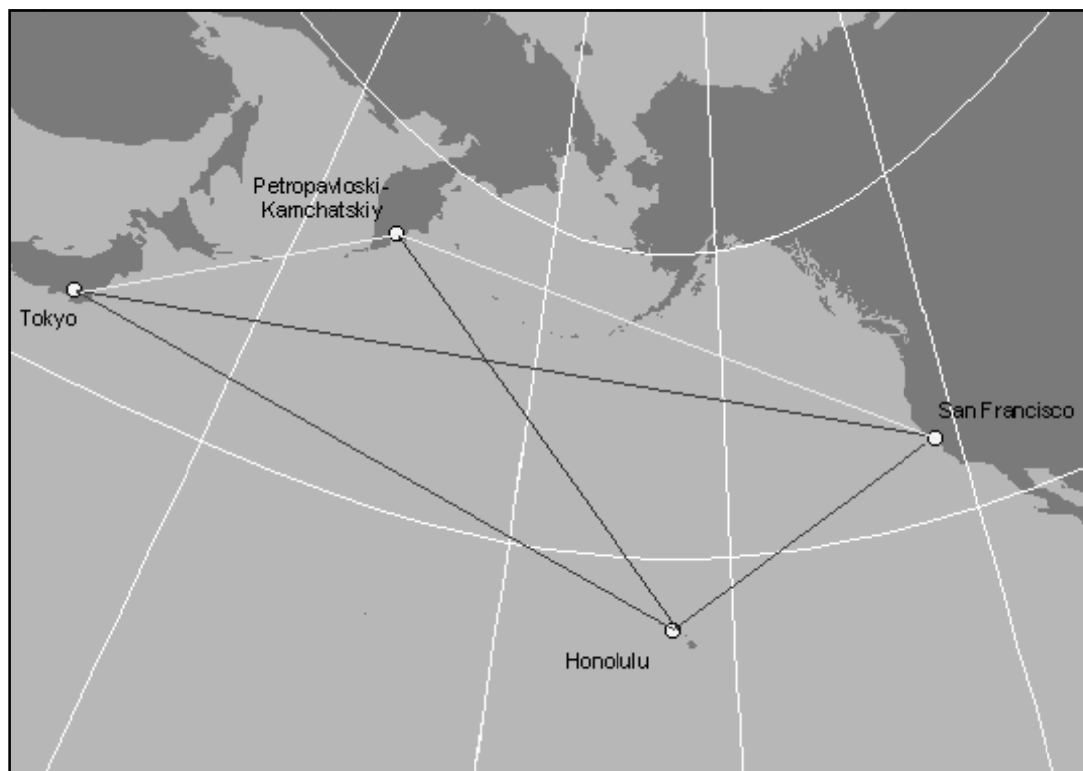


Figure 8: A Gnomonic projection. Every straight line on the map is the shortest distance between two points. The lines do not have true scale, however (ESRI).

INFORMATION CONTENT OF MAPS

The information conveyed by a map projection grid system is limited to one category only: absolute location of points on the Earth's surface. To be more useful, maps also carry other types of information. Map sheets published by national governments, such as this one, are usually multipurpose maps. Using a great variety of symbols, patterns, and colours, these maps carry a high information content. In contrast to the multipurpose map is the *thematic map*, which shows only one type of information, or theme. (Introducing Physical Geography- Alan H. Strahler).

DEFINITION OF SURVEYING

In general, surveying is performed to determine the relative location or positioning of points on or near the earth's surface. More specifically, surveying is the science of making measurements, relative to known or assumed datum's and standards, and applying the principles of mathematics to such measurements to determine existing or future horizontal and vertical position, from area, magnitude, boundaries, and extent of land parcels and topographical features. Surveying encompasses the following categories:

1. Geodetic Surveys - Surveys, which establish control networks on a mathematical datum so that measurements will reflect the curved (ellipsoidal) shape of the earth.
2. Land Surveys - Surveys which include retracement of existing land ownership boundaries or the creation of new boundaries.
3. Engineering Surveys - Surveys performed for the location, design, construction, maintenance and operation of engineering projects.
4. Construction Surveys - Surveys which establish stakes in the ground, and other like reference points, at known horizontal and vertical positions to define location and size of each component of the facility to be constructed, enable inspection of contract items, and serve as a basis of payment for work.
5. Cartographic Surveys - Map making from original surveys.

THEODOLITES

1. Definition - "theodolite" refers to a tribrach-mounted, closed, optical-reading, angle-measuring instrument with an optical plummet. That is, a theodolite is secured to a tripod by its separate base, the tribrach; the circles are read through a microscope and prism system; and it can be plumbed over a point without using a plumb bob. (The term "transit" is limited to an instrument that has open circles and verniers that must be read directly with the naked eye or with the aid of a hand-held magnifier.)

2. Tribrachs – A tribrach is the base of an instrument and it contains the leveling screws and the 5/8" X 11 female thread that accepts the tripod's instrument fastener screw.

3. Vertical Circle and Telescope Orientation – Theodolites used by the Division have vertical circles that are zenith oriented (telescope pointed overhead) at zero degrees. When the telescope is horizontal and the vertical circle is to the left of the line of sight, the vertical circle "reads" 90 degrees. This attitude of the theodolite is called "circle left", "face I" or

the "direct" position. In the "reverse" position ("face II" or circle right") the vertical circle is to the right of the line of sight. In this attitude the vertical circle "reads" 270 degrees when the telescope is horizontal.

4. Basic Types - Two basic types of theodolites are manufactured. a. Repeating Theodolites - These instruments can be used to measure a horizontal angle by repeating (or accumulating) the angle. The horizontal circle can be turned independently about the vertical axis or it can be turned with the alidade. A measured angle, either horizontal or vertical, is read internally at one point on the circle through the reading microscope. Repeating theodolites are generally graduated to 20 seconds or one minute; however, 10- second and 30-second models are manufactured. Most one-minute repeating theodolites marketed in the United States have horizontal circles, which are graduated clockwise and counter clockwise. Other repeating theodolites, and some one-minute instruments, are numbered only in one direction - clockwise or to the right. Certain makes of one-minute theodolites are available with

either type of graduation. Repeating theodolites are used primarily on design surveys and on construction staking. They are not to be used for precise control surveys. b. Direction Theodolites - In these instruments the horizontal circle cannot be moved by rotating the alidade; it is moved by a "circle drive knob". After initial pointing the horizontal circle remains fixed during a set of observations. Angles cannot be accumulated or repeated. The horizontal circle is single-numbered, clockwise-graduated and read through a reading microscope. A single microscope reading is a mean of readings on two diametrically opposite points on the circle. Thus, errors of circle eccentricity are eliminated (Survey Field Procedures Manual, 2001).

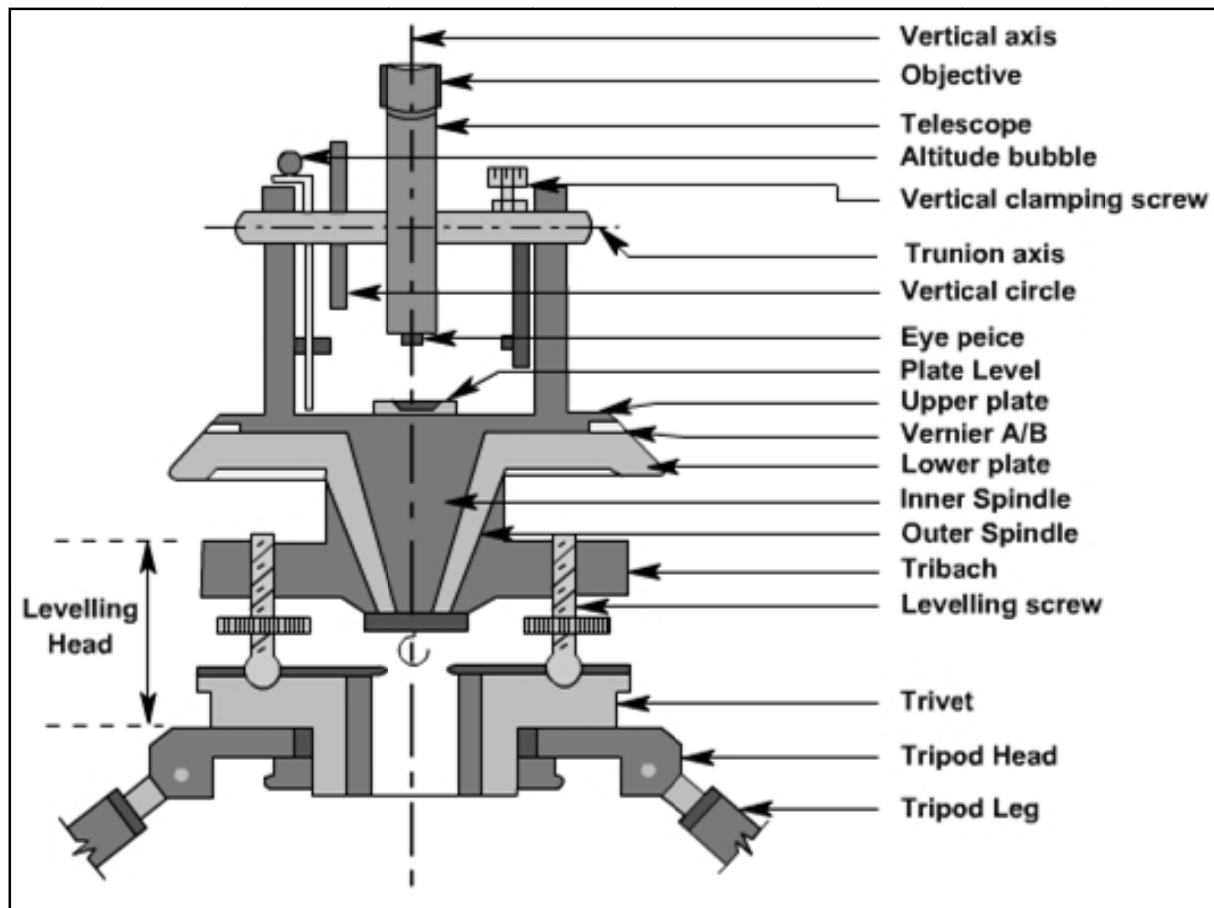


Figure 5: Sectional view of a Theodolite

UNIT-5

CONCEPT OF SOCIETY AND SPACE, MATERIAL AND SOCIAL SPACE, SOCIAL STRUCTURE AND SOCIAL PROCESSES, CULTURAL REALMS, CULTURAL DIFFUSION

A **society** is a group of individuals involved in persistent social interaction, or a large social group sharing the same geographical or social territory, typically subject to the same political authority and dominant cultural expectations. Societies are characterized by patterns of relationships (social relations) between individuals who share a distinctive culture and institutions; a given society may be described as the sum total of such relationships among its constituent of members. In the social sciences, a larger society often exhibits stratification or dominance patterns in subgroups.

Insofar as it is collaborative, a society can enable its members to benefit in ways that would not otherwise be possible on an individual basis; both individual and social (common) benefits can thus be distinguished, or in many cases found to overlap. A society can also consist of like-minded people governed by their own norms and values within a dominant, larger society. This is sometimes referred to as a subculture, a term used extensively within criminology.

More broadly, and especially within structuralist thought, a society may be illustrated as an economic, social, industrial or cultural infrastructure, made up of, yet distinct from, a varied collection of individuals. In this regard society can mean the objective relationships people have with the material world and with other people, rather than "other people" beyond the individual and their familiar social environment.

Etymology and usage

The term "society" came from the Latin word *societas*, which in turn was derived from the noun *socius* ("comrade, friend, ally"; adjectival form *socialis*) used to describe a bond or interaction between parties that are friendly, or at least civil. Without an article, the term can refer to the entirety of humanity (also: "society in general", "society at large", etc.), although those who are unfriendly or uncivil to the remainder of society in this sense may be deemed to be "antisocial". However, the Scottish economist, Adam Smith taught instead that a society "may subsist among different men, as among different merchants, from a sense of its utility without any mutual love or affection, if only they refrain from doing injury to each other."

Used in the sense of an association, a society is a body of individuals outlined by the bounds of functional interdependence, possibly comprising characteristics such as national or cultural identity, social solidarity, language, or hierarchical structure.

Conceptions

Society, in general, addresses the fact that an individual has rather limited means as an autonomous unit. The great apes have always been more (*Bonobo*, *Homo*, *Pan*) or less (*Gorilla*, *Pongo*) social animals, so Robinson Crusoe-like situations are either fictions or unusual corner cases to the ubiquity of social context for humans, who fall between presocial and eusocial in the spectrum of animal ethology.

Cultural relativism as a widespread approach or ethic has largely replaced notions of "primitive", better/worse, or "progress" in relation to cultures (including their material culture/technology and social organization).

According to anthropologist Maurice Godelier, one critical novelty in society, in contrast to humanity's closest biological relatives (chimpanzees and bonobos), is the parental role assumed by the males, which supposedly would be absent in our nearest relatives for whom paternity is not generally determinable.

In political science

Societies may also be structured politically. In order of increasing size and complexity, there are bands, tribes, chiefdoms, and state societies. These structures may have varying degrees of political power, depending on the cultural, geographical, and historical environments that these societies must contend with. Thus, a more isolated society with the same level of technology and culture as other societies is more likely to survive than one in close proximity to others that may encroach on their resources. A society that is unable to offer an effective response to other societies it competes with will usually be subsumed into the culture of the competing society.

In sociology

Sociologist Peter L. Berger defines society as "...a human product, and nothing but a human product, that yet continuously acts upon its producers." According to him, society was created by humans but this creation turns back and creates or molds humans every day.

Sociologist Gerhard Lenski differentiates societies based on their level of technology, communication, and economy: (1) hunters and gatherers, (2) simple agricultural, (3) advanced agricultural, (4) industrial, and (5) special (e.g. fishing societies or maritime societies). This is similar to the system earlier developed by anthropologists Morton H. Fried, a conflict theorist, and Elman Service, an integration theorist, who have produced a system of classification for societies in all human cultures based on the evolution of social inequality and the role of the state. This system of classification contains four categories:

- Hunter-gatherer bands (categorization of duties and responsibilities).
- Tribal societies in which there are some limited instances of social rank and prestige.
- Stratified structures led by chieftains.
- Civilizations, with complex social hierarchies and organized, institutional governments.

In addition to this there are:

- Humanity, humankind, upon which rest all the elements of society, including society's beliefs.
- Virtual society, a society based on online identity, which is evolving in the information age.

Over time, some cultures have progressed toward more complex forms of organization and control. This cultural evolution has a profound effect on patterns of community. Hunter-gatherer tribes settled around seasonal food stocks to become agrarian villages. Villages grew to become towns and cities. Cities turned into city-states and nation-states.

Many societies distribute largess at the behest of some individual or some larger group of people. This type of generosity can be seen in all known cultures; typically, prestige accrues to the generous

individual or group. Conversely, members of a society may also shun or scapegoat members of the society who violate its norms. Mechanisms such as gift-giving, joking relationships and scapegoating, which may be seen in various types of human groupings, tend to be institutionalized within a society. Social evolution as a phenomenon carries with it certain elements that could be detrimental to the population it serves.

Some societies bestow status on an individual or group of people when that individual or group performs an admired or desired action. This type of recognition is bestowed in the form of a name, title, manner of dress, or monetary reward. In many societies, adult male or female status is subject to a ritual or process of this type. Altruistic action in the interests of the larger group is seen in virtually all societies. The phenomena of community action, shunning, scapegoating, generosity, shared risk, and reward are common to many forms of society.

Types

Societies are social groups that differ according to subsistence strategies, the ways that humans use technology to provide needs for themselves. Although humans have established many types of societies throughout history, anthropologists tend to classify different societies according to the degree to which different groups within a society have unequal access to advantages such as resources, prestige, or power. Virtually all societies have developed some degree of inequality among their people through the process of social stratification, the division of members of a society into levels with unequal wealth, prestige, or power. Sociologists place societies in three broad categories: pre-industrial, industrial, and postindustrial.

Pre-industrial

In a pre-industrial society, food production, which is carried out through the use of human and animal labor, is the main economic activity. These societies can be subdivided according to their level of technology and their method of producing food. These subdivisions are hunting and gathering, pastoral, horticultural, agricultural, and feudal.

Hunting and gathering

The main form of food production in such societies is the daily collection of wild plants and the hunting of wild animals. Hunter-gatherers move around constantly in search of food. As a result, they do not build permanent villages or create a wide variety of artifacts, and usually only form small groups such as bands and tribes. However, some hunting and gathering societies in areas with abundant resources lived in larger groups and formed complex hierarchical social structures such as chiefdom. The need for mobility also limits the size of these societies. They generally consist of fewer than 60 people and rarely exceed 100. Statuses within the tribe are relatively equal, and decisions are reached through general agreement. The ties that bind the tribe are more complex than those of the bands. Leadership is personal—charismatic—and used for special purposes only in tribal society. There are no political offices containing real power, and a chief is merely a person of influence, a sort of adviser; therefore, tribal consolidations for collective action are not governmental. The family forms the main social unit, with most members being related by birth or marriage. This type of organization requires the family to carry out most social functions, including production and education.

Pastoral

Pastoralism is a slightly more efficient form of subsistence. Rather than searching for food on a daily basis, members of a pastoral society rely on domesticated herd animals to meet their food needs.

Pastoralists live a nomadic life, moving their herds from one pasture to another. Because their food supply is far more reliable, pastoral societies can support larger populations. Since there are food surpluses, fewer people are needed to produce food. As a result, the division of labour (the specialization by individuals or groups in the performance of specific economic activities) becomes more complex. For example, some people become craft workers, producing tools, weapons, and jewelry. The production of goods encourages trade. This trade helps to create inequality, as some families acquire more goods than others do. These families often gain power through their increased wealth. The passing on of property from one generation to another helps to centralize wealth and power. Over time emerge hereditary chieftainships, the typical form of government in pastoral societies.

Horticultural

Fruits and vegetables grown in garden plots that have been cleared from the jungle or forest provide the main source of food in a horticultural society. These societies have a level of technology and complexity similar to pastoral societies. Some horticultural groups use the slash-and-burn method to raise crops. The wild vegetation is cut and burned, and ashes are used as fertilizers. Horticulturists use human labour and simple tools to cultivate the land for one or more seasons. When the land becomes barren, horticulturists clear a new plot and leave the old plot to revert to its natural state. They may return to the original land several years later and begin the process again. By rotating their garden plots, horticulturists can stay in one area for a fairly long period of time. This allows them to build semi permanent or permanent villages. The size of a village's population depends on the amount of land available for farming; thus villages can range from as few as 30 people to as many as 2000.

As with pastoral societies, surplus food leads to a more complex division of labour. Specialized roles in horticultural societies include craftspeople, shamans (religious leaders), and traders. This role specialization allows people to create a wide variety of artifacts. As in pastoral societies, surplus food can lead to inequalities in wealth and power within horticultural political systems, developed because of the settled nature of horticultural life.

Agrarian

Agrarian societies use agricultural technological advances to cultivate crops over a large area. Sociologists use the phrase agricultural revolution to refer to the technological changes that occurred as long as 8,500 years ago that led to cultivating crops and raising farm animals. Increases in food supplies then led to larger populations than in earlier communities. This meant a greater surplus, which resulted in towns that became centers of trade supporting various rulers, educators, craftspeople, merchants, and religious leaders who did not have to worry about locating nourishment.

Greater degrees of social stratification appeared in agrarian societies. For example, women previously had higher social status because they shared labour more equally with men. In hunting and gathering societies, women even gathered more food than men. However, as food stores improved and women took on lesser roles in providing food for the family, they increasingly became subordinate to men. As villages and towns expanded into neighbouring areas, conflicts with other communities inevitably occurred. Farmers provided warriors with food in exchange for protection against invasion by enemies. A system of rulers with high social status also appeared. This nobility organized warriors to protect the society from invasion. In this way, the nobility managed to extract goods from “lesser” members of society.

Feudal

Feudalism was a form of society based on ownership of land. Unlike today's farmers, vassals under feudalism were bound to cultivating their lord's land. In exchange for military protection, the lords exploited the peasants into providing food, crops, crafts, homage, and other services to the landowner. The estates of the realm system of feudalism was often multigenerational; the families of peasants may have cultivated their lord's land for generations.

Industrial

Between the 15th and 16th centuries, a new economic system emerged that began to replace feudalism. Capitalism is marked by open competition in a free market, in which the means of production are privately owned. Europe's exploration of the Americas served as one impetus for the development of capitalism. The introduction of foreign metals, silks, and spices stimulated great commercial activity in European societies.

Industrial societies rely heavily on machines powered by fuels for the production of goods. This produced further dramatic increases in efficiency. The increased efficiency of production of the industrial revolution produced an even greater surplus than before. Now the surplus was not just agricultural goods, but also manufactured goods. This larger surplus caused all of the changes discussed earlier in the domestication revolution to become even more pronounced.

Once again, the population boomed. Increased productivity made more goods available to everyone. However, inequality became even greater than before. The breakup of agricultural-based feudal societies caused many people to leave the land and seek employment in cities. This created a great surplus of labor and gave capitalists plenty of laborers who could be hired for extremely low wages.

Post-industrial

Post-industrial societies are societies dominated by information, services, and high technology more than the production of goods. Advanced industrial societies are now seeing a shift toward an increase in service sectors over manufacturing and production. The United States is the first country to have over half of its work force employed in service industries. Service industries include government, research, education, health, sales, law, and banking.

Contemporary usage

The term "society" is currently used to cover both a number of political and scientific connotations as well as a variety of associations.

Western

The development of the Western world has brought with it the emerging concepts of Western culture, politics, and ideas, often referred to simply as "Western society". Geographically, it covers at the very least the countries of Western Europe, North America, Australia, and New Zealand. It sometimes also includes Eastern Europe, South America, and Israel.

The cultures and lifestyles of all of these stem from Western Europe. They all enjoy relatively strong economies and stable governments, allow freedom of religion, have chosen democracy as a form of governance, favor capitalism and international trade, are heavily influenced by Judeo-Christian values, and have some form of political and military alliance or cooperation.

Information

Although the concept of information society has been under discussion since the 1930s, in the modern world it is almost always applied to the manner in which information technologies have impacted society and culture. It therefore covers the effects of computers and telecommunications on the home, the workplace, schools, government, and various communities and organizations, as well as the emergence of new social forms in cyberspace.

One of the European Union's areas of interest is the information society. Here policies are directed towards promoting an open and competitive digital economy, research into information and communication technologies, as well as their application to improve social inclusion, public services, and quality of life.

The International Telecommunications Union's World Summit on the Information Society in Geneva and Tunis (2003 and 2005) has led to a number of policy and application areas where action is envisaged.

Knowledge

As access to electronic information resources increased at the beginning of the 21st century, special attention was extended from the information society to the knowledge society. An analysis by the Irish government stated, "The capacity to manipulate, store and transmit large quantities of information cheaply has increased at a staggering rate over recent years. The digitisation of information and the associated pervasiveness of the Internet are facilitating a new intensity in the application of knowledge to economic activity, to the extent that it has become the predominant factor in the creation of wealth. As much as 70 to 80 percent of economic growth is now said to be due to new and better knowledge."

The Second World Summit on the Knowledge Society, held in Chania, Crete, in September 2009, gave special attention to the following topics:

- business and enterprise computing;
- technology-enhanced learning;
- social and humanistic computing;
- culture, tourism and technology;
- e-government and e-democracy;
- innovation, sustainable development, and strategic management;
- service science, management and engineering;
- intellectual and human capital development;
- ICTs for ecology and the green economy;
- future prospects for the knowledge society; and
- technologies and business models for the creative industries.

Other uses

People of many nations united by common political and cultural traditions, beliefs, or values are sometimes also said to form a society (such as Judeo-Christian, Eastern, and Western). When used in this context, the term is employed as a means of contrasting two or more "societies" whose members represent alternative conflicting and competing worldviews.

Some academic, professional, and scientific associations describe themselves as *societies* (for example, the American Mathematical Society, the American Society of Civil Engineers, or the Royal Society).

In some countries, e.g. the United States, France, and Latin America, the term "society" is used in commerce to denote a partnership between investors or the start of a business. In the United Kingdom, partnerships are not called societies, but co-operatives or mutuals are often known as societies (such as friendly societies and building societies).

SPACE

Definition of space

Space is one of the most important concepts within the disciplines of social science as it is fundamental to our understanding of geography. The term "space" has been defined variously by scholars:

In general terms, the Oxford English Dictionary defines space in two ways;

1. A continuous extension viewed with or without reference to the existence of objects within it. 2. The interval between points or objects viewed as having one, two or three dimensions.

However, the human geographers' interest is in the objects within the space and their relative position, which involves the description, explanation and prediction of the distribution of phenomena. Thus, the relationships between objects in space is the central of the study.

Michel Foucault defines space as; "The space in which we live, which draws us out of ourselves, in which the erosion of our lives, our time and our history occurs, the space that claws and gnaws at us, is also, in itself, a heterogeneous space.....we live inside a set of relations.

Nigel Thrift also defines space as; "The outcome of a series of highly problematic temporary settlements that divide and connect things up into different kinds of collectives which are slowly provided with the meaning which render them durable and sustainable."

In short, "space" is the social space in which we live and create relationships with other people, societies and surroundings. Space is an outcome of the hard and continuous work of building up and maintaining collectives by bringing different things into alignments. All kinds of different spaces can and therefore do exist which may or may not relate to each other. Thus, through space, we can understand more about social action.

History of the sociology of space

Georg Simmel has been seen as the classical sociologist who was most important to this field. Simmel wrote on "the sociology of space" in his 1908 book "Sociology: Investigations on the Forms of Sociation". His concerns included the process of metropolitanisation and the separation of leisure spaces in modern economic societies.

The category of space long played a subordinate role in sociological theory formation. Only in the late 1980s did it come to be realised that certain changes in society cannot be adequately explained without taking greater account of the spatial components of life. This shift in perspective is referred to as the topological turn. The space concept directs attention to organisational forms of juxtaposition. The focus is on differences between places and their mutual influence. This applies equally for the micro-spaces of everyday life and the macro-spaces at the nation-state or global levels.

The theoretical basis for the growing interest of the social sciences in space was set primarily by English and French-speaking sociologists, philosophers, and human geographers. Of particular importance is Michel Foucault's essay on "Of Other Spaces", in which the author proclaims the "age of space", and Henri Lefebvre's seminal work "La production de l'espace". The latter provided the grounding for Marxist spatial theory on which David Harvey, Manuel Castells, Edward Soja, and others have built. Marxist theories of space, which are predicated on a structural, i.e., capitalist or global determinants of spaces and the growing homogenization of space, are confronted by action theoretical conceptions, which stress the importance of the corporeal placing and the perception of spaces as albeit habitually predetermined but subjective constructions. One example is the theory of space of the German sociologist Martina Löw. Approaches deriving from the post-colonialism discourse have attracted greater attention in recent years. Also in contrast to (neo) Marxist concepts of space, British geographer Doreen Massey and German sociologist Helmuth Berking, for instance, emphasise the heterogeneity of local contexts and the place-relatedness of our knowledge about the world.

Duality of space

Martina Löw developed the idea of a "relational" model of space, which focuses on the "orderings" of living entities and social goods, and examines how space is constituted in processes of perception, recall, or ideation to manifest itself as societal structure. From a social theory point of view, it follows on from the theory of structuration proposed by Anthony Giddens, whose concept of the "duality of structure" Löw extends sociological terms into a "duality of space." The basic idea is that individuals act as social agents (and constitute spaces in the process), but that their action depends on economic, legal, social, cultural, and, finally, spatial structures. Spaces are hence the outcome of action. At the same time, spaces structure action, that is to say spaces can both constrain and enable action.

With respect to the constitution of space, Löw distinguishes analytically between two, generally mutually determining factors: "spacing" and "synthesis." Spacing refers to the act of placing or the state of being placed of social goods and people in places. According to Löw, however, an ordering created through placings is only effectively constituted as space where the elements that compose it are actively interlinked by people – in processes of perception, ideation, or recall. Löw calls this synthesis. This concept has been empirically tested in studies such as those by Lars Meier (who examined the constitution of space in the everyday life of financial managers in London and Singapore), Cedric Janowicz (who carried out an ethnographical-space sociological study of food supply in the Ghanaian city of Accra), and Silke Streets (who looked at processes of space constitution in the creative industries in Leipzig).

Marxist approaches

The most important proponent of Marxist spatial theory was Henri Lefebvre. He proposed "social space" to be where the relations of production are reproduced and that dialectical contradictions were spatial rather than temporal. Lefebvre sees the societal production of space as a dialectical interaction between three factors. Space is constituted:

- by "spatial practice," meaning space as reproduced in everyday life
- by the "representation of space", meaning space as developed cognitively

- and by “spaces of representation,” by which Lefebvre means complex symbolisations and ideational spaces.

In Lefebvre’s view of the 1970s, this spatial production resulted in a space of non-reflexive everydayness marked by alienation, dominating through mathematical-abstract concepts of space, and reproduced in spatial practice. Lefebvre sees a line of flight from alienated spatiality in the spaces of representation – in notions of non-alienated, mythical, pre-modern, or artistic visions of space.

Marxist spatial theory was given decisive new impetus by David Harvey, in particular, who was interested in the effects of the transition from Fordism to “flexible accumulation” on the experience of space and time. He shows how various innovations at the economic and technological levels have breached the crisis-prone inflexibility of the Fordist system, thus increasing the turnover rate of capital. This causes a general acceleration of economic cycles. According to Harvey, the result is “time-space compression.” While the feeling for the long term, for the future, for continuity is lost, the relationship between proximity and distance becomes more and more difficult to determine.

Postcolonial theories of space

Theories of space that are inspired by the post-colonialism discourse focus on the heterogeneity of spaces. According to Doreen Massey, calling a country in Africa a “developing country” is not appropriate, since this expression implies that spatial difference is temporal difference (Massey 1999b). This logic treats such a country not as different but merely as an early version of countries in the “developed” world, a view she condemns as “Eurocentrism.” In this vein, Helmuth Berking criticises theories that postulate the increasing homogenisation of the world through globalisation as “globocentrism.” He confronts this with the distinctiveness and importance of local knowledge resources for the production of (different and specific) places. He claims that local contexts form a sort of framework or filter through which global processes and globally circulating images and symbols are appropriated, thus attaining meaning. For instance, the film character Conan the Barbarian is a different figure in radical rightwing circles in Germany than in the black ghettos of the Chicago Southside, just as McDonald’s means something different in Moscow than in Paris.

Third space

Henri Lefebvre (see also Edward Soja) says that (social) space is a (social) product, or a complex social construction (based on values, and the social production of meanings) which affects spatial practices and perceptions. He explains space embraces a multitude of intersection in his great book, “Production of Space”. That means that we need to consider how the various modes of spatial production relate to each other.

He argues that there are three aspects to our spatial existence, which exist in a kind of triad:

1. First Space (Physical space/perceived space) "The spatial practice of a society secretes that society's space; it propounds and presupposes it, in a dialectical interaction; it produces it slowly and surely as it masters and appropriates it."
2. Second Space (Mental space/conceived space) "Conceptualized space, the space of scientists, planners, urbanists, technocratic subdividers and social engineers, as of a certain type of artist with a scientific bent -- all of whom identify what is lived and what is perceived with what is conceived."
3. Third Space (Social space/lived space) "Space as directly lived through its associated images and symbols."

Even though there are many disciplines in the study of Human Geography, the most well-known approach is “The third space” formulated by Edward Soja. In unitary theory, there are three approaches; first space, second space and third space. First space is physical space, and spaces are measurable and mappable. The second space is a mental or conceived space which comes from our thinking and ideas. However, the third space is a social space/lived space which is a social product that is a space created by society under oppression or marginalization that want to reclaim the space of inequality and make it into something else. Soja argues that our old ways to thinking about space (first and second space theories) can no longer accommodate the way the world works because he believed that spaces may not be contained within one social category, they may include different aspects of many categories or developed within the boundaries of a number of category. For instance, two different cultures combine together and emerge as a third culture. This third hybrid space displaces the original values that constitute it and set up new values and perspectives that is different from the first two spaces. Thus, the third space theory can explain some of the complexity of poverty, social exclusion and social inclusion, gender and race issues.

Rational view of space

In the work of geographer and critical theorist Nigel Thrift, he wrote a rational view of space in which, rather than seeing space being viewed as a container within which the world proceeds, space should be seen as a co-product of these proceedings. He explained about four constructed space in modern human geography. There are four different kinds of space according to how modern geography thinks about space. They are 1. Empirical Construction of Space, 2. Unblocking space, 3. Image space and 4. Place Space.

First Space is the empirical construction of space. Empirical space refers to the process whereby the mundane fabric of daily life is constructed. These simple things like, cars, houses, mobiles, computers and roads are very simple but they are great achievements of our daily life and they play very important role in making up who we are today. For example, today’s technology such as GPS did not suddenly come into existence; in fact, it is laid down in the 18th century and developed throughout time. The first space is real and tangible, and it is also known as physical space. **Second space** is the unblocking space. This type of space refers to the process whereby routine pathways of interaction as set up around which boundaries are often drawn. The routine may include the movement of office workers, the interaction of drunk teenagers, and the flow of goods, money, people, and information. Unlike the old time in geography when people accepted a space as blocked boundary (Example: A capitalist space, neoliberal space or city space), we began to realize that there is no such thing like boundaries in space. The space of the world is flowing and transforming continuously that it is very difficult to describe in a fixed way. The second space is ideology/conceptual and it is also known as mental space. For example, the second space will explain the behaviors of people from different social class and the social segregation among rich and poor people. **Third space** is the image space that refers to the process whereby the images has produced new kind of space. The images may be in different form and shape; ranging from painting to photograph, from portrait to post card, and from religious theme to entertainment. Nowadays, we are highly influenced by images in many ways and these certain images can tell us new social and cultures values, or something new about how we see the world. Images, symbols and sign do have some kind of spatial expression. **Fourth space** is the place that refers to the process whereby spaces are ordered in ways that open up affective and other embodied potentials. Place space has more meaning than a place, and it can represent as different type of space. This fourth type of space tries to understand that place is a vital actor in bringing up people’s lives in certain ways and place will let us to understand all kind of things which are hidden form us..

Scale: the local and global

Andrew Herod mentioned that scale, within human geography, is typically seen in one of the two ways: either as a real material thing which actually exists and is the result of political struggle and/or social process, or as a way of framing our understanding of the world. People's lives across the globe have been re-scaling by contemporary economic, political, cultural and social processes, such as globalization, in complex ways. As a result, we have seen the creation of supra-national political bodies such as the European Union, the devolution of political power from the nation-state to regional political bodies. We have also experienced the increasing homogenization and 'Americanization' through the process of globalization while the locals' tendencies (or counter force) among people who defend traditional ways of life increase around the world. The process of re-scaling people's lives and the relationship between the two extremes of our scaled lives- the 'global' and the 'local' were brought into question.

Ontological status of the global and the local

Until the 1980s, theorizing the concept of 'scale' itself was taken for granted although physical and human geographers looked at issues from 'regional scale' or 'national scale'. The questions such as whether scale is simply a mental device categorizing and ordering the world or whether scales really exist as material social products, particularly, were debated among materialists and idealists. Some geographers draw upon Immanuel Kant's idealist philosophy that scales were handy conceptual mechanism for ordering the world while others, by drawing upon Marxist ideas of materialism, argue that scales really exist in the world and they were the real social products. For those idealists based on Kantian's inspiration, the 'global' is defined by the geologically given limits of the earth and the 'local' is defined as a spatial resolution useful for comprehending the process and practices. For materialists, the 'national' scale is a scale that had to be actively created through economic and political processes but not a scale existed in a logical hierarchy between global and the regional.

The notion of 'becoming' and the focus on the politics of producing scales have been central to materialist arguments concerning the global scale. It is important to recognize that social actors may have to work just as hard to become 'local' as they have to work to become 'global'. People paid attention to how transnational corporations have 'gone global', how institutions of governance have 'become' supra-national and how labour unions have sought to 'globalize' their operations to match those of an increasingly 'globalized' city.

For the scale 'global' and 'local', Kevin Cox mentioned that moving from the local to the global scale 'is not a movement from one discrete arena to another' but a process of developing networks of associations that allow actors to shift between various spaces of engagement. According to his view, 'scale' is seen as a process rather than as a fixed entity and, in other words, the global and the local are not static 'arenas' within which social life plays out but are constantly made by social actions. For example, a political organization might attempt to go 'global' to engage with actors or opportunities outside of its own space; likewise, a transnational corporation may attempt to 'go local' through tailoring its products and operations in different places.

Discourses of the global and the local

Gibson-Graham (2002) has identified at least six ways in which the relationship between the local and the global is often viewed.

1. The global and the local are seen as interpretive frames for analyzing situations

2. Drawing on Dirlik, Gibson-Graham suggests that in such a representation, the global is ‘something more than the national or regional, anything other than the local’. Meaning that, the global and the local each derive meaning from what they are not.

3. According to French social theorist Bruno Latour, the local and the global ‘offer different points of view on networks that are by nature neither local nor global, but are more or less long and more or less connected. Also, in Latour’s view, it is impossible to distinguish where the local ends and the global begins.

4. The concept ‘The global is local’ was proposed by Gibson-Graham. For instance, multinational firms are actually ‘multi local’ rather than ‘global’.

5. The local is global. In this view, the local is an entry point to the world of global flows which encircle the planet.

6. The global and the local are actually the processes rather than the locations. All spaces are the hybrids of global and local; so they are ‘glocal.’

There are some western thoughts that greater size and extensiveness imply domination and superior power, such that the local is often represented as ‘small and relatively powerless, defined and confined by the global’. So, the global is a force and the local is its field of play. However, the local can serve as a powerful scale of political organization; the global is not a scale just controlled by capital – those who challenge capital can also organize globally(Herod, A). There has been the concept ‘Think globally and act locally’ viewed by neoliberals.

Metaphors of scale

For representing how the world is scaled, there are five different and popular metaphors: they are the ladder, concentric circles, Matryoshka nesting dolls, earthworm burrows and tree roots. First, in using such a metaphor of hierarchical ladder, the global as the highest rung on the ladder is seen to be above the local and all other scales. Second, the use of concentric metaphor leaves us with a particular way of conceptualizing the scalar relationship between places. In this second metaphor, the local is seen as a relatively small circle, with the regional as a larger circle encompassing it, while the national and the global scales are still larger circles encompassing the local and the regional. For the hierarchy of Russian Matryoshka nesting dolls, the global can contain other scales but this does not work the other way round; for instance, the local cannot contain the global. For the fourth metaphor concerning with thinking on scale, what French social theorist Bruno Latour argued is that a world of places is ‘networked’ together. Such the metaphor leaves us with an image of scale in which the global and the local are connected together and not totally separated from each other. For the tree roots metaphor similar with the earthworm burrow metaphor, as the earthworm burrows or tree roots penetrating different strata of the soil, it is difficult to determine exactly where one scale ends and another begins. When thinking about the use of metaphor, it should be aware that the choice of metaphor over another is not made on the basis of which is empirically a ‘more accurate’ representation of something but, on the basis of how someone is attempting to understand a particular phenomenon.

Such an appreciation of metaphors is important because it suggests that how we talk about scale impacts upon the ways in which we engage socially and politically with our scaled world and that may impact on how we conduct our social, economic and political praxis and so make landscapes (Sociology of space).

CULTURAL REALMS

In anthropology and geography, a **cultural region**, **cultural sphere**, **cultural area** or **culture area** refers to geography with one relatively homogeneous human activity or complex of activities (culture). These are often associated with an ethnolinguistic group and the territory it inhabits. Specific cultures often do not limit their geographic coverage to the borders of a nation state, or to smaller subdivisions of a state. Cultural "spheres of influence" may also overlap or form concentric structures of macrocultures encompassing smaller local cultures. Different boundaries may also be drawn depending on the particular aspect of interest, such as religion and folklore vs. dress and architecture vs. language.

Cultural areas are not considered equivalent to *Kulturkreis* (Culture circles).

History of concept

A culture area is a concept in cultural anthropology in which a geographic region and time sequence (age area) is characterized by substantially uniform environment and culture. The concept of culture areas was originated by museum curators and ethnologists during the late 1800s as means of arranging exhibits. Clark Wissler and Alfred Kroeber further developed the concept on the premise that they represent longstanding cultural divisions. The concept is criticized by some, who argue that the basis for classification is arbitrary. But other researchers disagree and the organization of human communities into cultural areas remains a common practice throughout the social sciences. The definition of culture areas is enjoying a resurgence of practical and theoretical interest as social scientists conduct more research on processes of cultural globalization.

Types

A formal culture region is an area inhabited by people who have one or more cultural traits in common, such as language, religion, or system of livelihood. It is an area relatively homogeneous with regard to one or more cultural traits. The geographer who identifies a formal culture region must locate cultural borders. Because cultures overlap and mix, such boundaries are rarely sharp even if only one cultural trait is mapped and so there are cultural border zones, rather than lines. The zones broaden with each additional cultural trait that is considered because no two traits have the same spatial distribution. As a result, instead of having clear borders, formal culture regions reveal a center or core, where the defining traits are all present. Away from the central core, the characteristics weaken and disappear. Thus, many formal culture regions display a core-periphery.

In contrast to the abstract cultural homogeneity of a formal culture region, a functional culture region may not be culturally homogeneous; instead, it is an area that has been organized to function politically, socially, or economically as one unit: a city, an independent state, a precinct, a church diocese or parish, a trade area or a farm. Functional culture regions have nodes or central points where the functions are coordinated and directed, such as city halls, national capitols, precinct voting places, parish churches, factories, and banks. In that sense, functional regions also possess a core-periphery configuration, in common with formal culture regions. Many functional regions have clearly defined borders that include all land under the jurisdiction of a particular urban government that is clearly delineated on a regional map by a line distinguishing between one jurisdiction and another.

Vernacular, popular or perceptual cultural regions are those perceived to exist by their inhabitants, as is evident by the widespread acceptance and use of a distinctive regional name. Some vernacular regions are based on physical environmental features; others find their basis in economic, political or historical characteristics. Vernacular regions, like most culture regions, generally lack sharp borders,

and the inhabitants of any given area may claim residence in more than one such region. It grows out of people's sense of belonging and identification with a particular region. An American example is "Dixie". They often lack the organization necessary for functional regions although they may be centered on a single urban node. They frequently do not display the cultural homogeneity that characterizes formal regions.

Allen Noble gave a summary of the concept development of cultural regions using the terms "cultural hearth" (no origin of this term given), "cultural core" by Donald W. Meinig for Mormon culture published in 1970 and "source area" by Fred Kniffen (1965) and later Henry Glassie (1968) for house and barn types. Outside of a core area he quoted Meinigs' use of the terms "domain" (a dominant area) and "sphere" (area influenced but not dominant).

Cultural boundary

A cultural boundary (also cultural border) in ethnology is a geographical boundary between two identifiable ethnic or ethnolinguistic cultures. A language border is necessarily also a cultural border, as language is a significant part of a society's culture), but it can also divide subgroups of the same ethnolinguistic group along more subtle criteria, such as the Brünig-Napf-Reuss line in German-speaking Switzerland, the Weißwurstäquator in Germany or the Grote rivieren boundary between Dutch and Flemish culture.

In the history of Europe, the major cultural boundaries are found:

- in Western Europe between Latin Europe, where the legacy of the Roman Empire remained dominant, and Germanic Europe, where it was significantly syncretized with Germanic culture
- in the Balkans, the Jireček Line, dividing the area of dominant Latin (Western Roman Empire) from that of dominant Greek (Eastern Roman Empire) influence.

Macro-cultures on a continental scale are also referred to as "worlds," "spheres," or "civilizations," such as the Muslim world.

In a modern context, a cultural boundary can also be a division between subcultures or classes within a given society, such as blue collar vs. white collar etc.

- See also: Isogloss

Role in conflict

Cultural boundaries sometimes define the difference between friend and foe in political and military conflicts. Ethnic nationalism and pan-nationalism sometimes seek to unify all native speakers of a particular language, who are conceived of as a coherent ethnic group or nation, into a single nation-state with a unified culture. The association of an ethnolinguistic group with a nation-state may be written into nationality laws and repatriation laws, which establish eligibility for citizenship based on ethnicity, rather than place of birth.

In other cases, attempts have been made to divide countries based on cultural boundaries by secession or partition. For example, the Quebec sovereignty movement seeks to separate French-speaking province from English-speaking Canada to preserve its unique language and culture, and the Partition of India created separate majority-Hindu and majority-Muslim countries.

Examples

- East–West dichotomy: The Western civilization and Western world contrasting with the Orient and Eastern world.
- North–South divide: The North–South divide is broadly considered a socio-economic and political divide.
- Geographic
 - o Americas [see also Americas (terminology)]
 - Caribbean
 - Central America
 - Mesoamerica
 - North America
 - Northern America
 - South America
 - o British Isles
 - o Eastern world
 - Far East
 - Middle East
 - Near East
 - o Indian subcontinent
 - o Maghreb
 - o Southeast Asia
 - Mainland Southeast Asia and Indochina
 - Maritime Southeast Asia
 - o Turkestan
- Based on language or language families:
 - o Arab World, Arab-speaking world, and Arab diaspora
 - o Celts and Celtic Europe
 - o English-speaking world (Anglophone)
 - o Finnic peoples
 - o Francophonie (see also Françafrique)

- o German language in Europe
- o Germanic-speaking Europe
- o Hindi Belt (Hindi-Urdu Region)
- o Hispanidad
- o Hispanophone
- o Indigenous peoples of the Americas
 - Indigenous peoples of South America
 - Indigenous peoples of the Pacific Northwest Coast
 - Native Americans in the United States
- o Latin America
 - French America
 - Hispanic America
 - Ibero-America
 - Lusophone
- o Mainland Southeast Asia linguistic area
- o Latin Europe
- o Sinophone
- o Slavic Europe
- Based on cultures
 - o Anglosphere
 - o East Asian cultural sphere (Sinosphere)
 - o Greater China
 - o Greater India and Indosphere
 - o Greater Iran (Greater Persia)
 - o Greater Middle East
 - o Lusosphere
 - o Nordic countries (speaking North Germanic languages)

- Based on religious beliefs
 - o Arab World
 - Islam by country
 - o Buddhism by country
 - o Christendom (Christian world)
 - Christianity by country
 - o Hinduism by country
 - o Islamic state
 - Islamic republic
 - Islamic monarchy
 - o Muslim world

Music

A **music area** is a cultural area defined according to musical activity. It may or may not conflict with the cultural areas assigned to a given region. The world may be divided into three large music areas, each containing a "cultivated" or classical musics "that are obviously its most complex musical forms," with, nearby, folk styles which interact with the cultivated, and, on the perimeter, primitive styles:

- Europe and Sub-Saharan Africa
 - o based on shared isometric materials, diatonic scales, and polyphony based on parallel thirds, fourths, and fifths.
 - o would usually use the natural major scale and minor scale, and Dorian, Lydian and Mixolydian modes.
- North Africa, Southwest Asia, Central Asia, South Asia, Indonesia and parts of Southern Europe.
 - o based on shared small intervals in scales, melodies, and polyphony.
 - o would usually use the harmonic minor scale and the Phrygian scale.
- American Indian, East Asia, Northern Siberian, and Finno-Ugric music
 - o based on shared large steps in pentatonic and tetratonic scales.

However, he then adds that "the world-wide development of music must have been a unified process in which all peoples participated" and that one finds similar tunes and traits in puzzlingly isolated or separated locations throughout the world (Cultural area).

Cultural Diffusion

In cultural anthropology and cultural geography, **cultural diffusion**, as conceptualized by Leo Frobenius in his 1897/98 publication *Der westafrikanische Kulturkreis*, is the spread of cultural items—such as ideas, styles, religions, technologies, languages—between individuals, whether within a single culture or from one culture to another. It is distinct from the diffusion of innovations within a specific culture. Examples of diffusion include the spread of the war chariot and iron smelting in ancient times, and the use of automobiles and Western business suits in the 20th century.

Types

Five major types of cultural diffusion have been defined:

- Expansion diffusion: an innovation or idea that develops in a source area and remains strong there, while also spreading outward to other areas. This can include hierarchical, stimulus, and contagious diffusion.
- Relocation diffusion: an idea or innovation that migrates into new areas, leaving behind its origin or source of the cultural trait.
- Hierarchical diffusion: an idea or innovation that spreads by moving from larger to smaller places, often with little regard to the distance between places, and often influenced by social elites.
- Contagious diffusion: an idea or innovation that spreads based on person-to-person contact within a given population.
- Stimulus diffusion: an idea or innovation that spreads based on its attachment to another concept.

Mechanisms

Inter-cultural diffusion can happen in many ways. Migrating populations will carry their culture with them. Ideas can be carried by trans-cultural visitors, such as merchants, explorers, soldiers, diplomats, slaves, and hired artisans. Technology diffusion has often occurred by one society luring skilled scientists or workers by payments or other inducement. Trans-cultural marriages between two neighboring or interspersed cultures have also contributed. Among literate societies, diffusion can occur through letters, books, and, in modern times, through electronic media.

There are three categories of diffusion mechanisms:

- **Direct diffusion** occurs when two cultures are very close to each other, resulting in intermarriage, trade, and even warfare. An example of direct diffusion is between the United States and Canada, where the people living on the border of these two countries engage in hockey, which started in Canada, and baseball, which is popular in American culture.
- **Forced diffusion** occurs when one culture subjugates (conquers or enslaves) another culture and forces its own customs on the conquered people. An example would be the forced Christianization of the indigenous peoples of the Americas by the Spanish, French, English and Portuguese, or the forced Islamization of West African peoples by the Fula or of the Nuristanis by the Afghans.

- **Indirect diffusion** happens when traits are passed from one culture through a middleman to another culture, without the first and final cultures being in direct contact. An example could be the presence of Mexican food in Canada, since a large territory (the United States) lies between.

Direct diffusion was common in ancient times, when small groups of humans lived in adjoining settlements. Indirect diffusion is common in today's world because of the mass media and invention of the Internet. Also of interest is the work of American historian and critic Daniel J. Boorstin in his book *The Discoverers*, in which he provides an historical perspective on the role of explorers in the diffusion of innovations between civilizations.

Theories

The many models that have been proposed for inter-cultural diffusion are:

- Migrationism, the spread of cultural ideas by either gradual or sudden population movements
- Culture circles diffusionism (*Kulturkreise*)—the theory that cultures originated from a small number of cultures
- "*Kulturkugel*" (a German compound meaning "culture bullet", coined by J. P. Mallory), a mechanism suggested by Mallory to model the scale of invasion vs. gradual migration vs. diffusion. According to this model, local continuity of material culture and social organization is stronger than linguistic continuity, so that cultural contact or limited migration regularly leads to linguistic changes without affecting material culture or social organization.
- Hyperdiffusionism—the theory that all cultures originated from one culture

A concept that has often been mentioned in this regard, which may be framed in the evolutionary diffusionism model, is that of "an idea whose time has come" — whereby a new cultural item appears almost simultaneously and independently in several widely separated places, after certain prerequisite items have diffused across the respective communities. This concept was invoked with regard to the independent development of calculus by Newton and Leibnitz, and the inventions of the airplane and of the electronic computer.

Hyperdiffusionism

Hyperdiffusionists deny that parallel evolution or independent invention took place to any great extent throughout history; they claim that all major inventions and all cultures can be traced back to a single culture.

Early theories of hyperdiffusionism can be traced to ideas about South America being the origin of mankind. Antonio de León Pinelo, a Spaniard who settled in Bolivia, claimed in his book *Paraíso en el Nuevo Mundo* that the Garden of Eden and the creation of man had occurred in present-day Bolivia and that the rest of the world was populated by migrations from there. Similar ideas were also held by Emeterio Villamil de Rada; in his book *La Lengua de Adán* he attempted to prove that Aymara was the original language of mankind and that humanity had originated in Sorata in the Bolivian Andes. The first scientific defence of humanity originating in South America came from the Argentine paleontologist Florentino Ameghino in 1880, who published his research in *La antigüedad del hombre en el Plata*.

The work of Grafton Elliot Smith fomented a revival of hyperdiffusionism in 1911; he asserted that copper-producing knowledge spread from Egypt to the rest of the world along with megalithic culture. Smith claimed that all major inventions had been made by the ancient Egyptians and were carried to the rest of the world by migrants and voyagers. His views

became known as "Egyptocentric-Hyperdiffusionism". William James Perry elaborated on Smith's hypothesis by using ethnographic data. Another hyperdiffusionist was Lord Raglan; in his book *How Came Civilization* (1939) he wrote that instead of Egypt all culture and civilization had come from Mesopotamia. Hyperdiffusionism after this did not entirely disappear, but it was generally abandoned by mainstream academia.

Medieval Europe

Diffusion theory has been advanced as an explanation for the "European miracle", the adoption of technological innovation in medieval Europe which by the 17th century culminated in European technological achievement surpassing the Islamic world and China. Such technological import to medieval Europe include gunpowder, clock mechanisms, shipbuilding, paper and the windmill, however, in each of these cases Europeans not only adopted the technologies, but improved the manufacturing scale, inherent technology, and applications to a point clearly surpassing the evolution of the original invention in its country of origin.

Historians have questioned recently whether Europe really owes the development of such inventions as gunpowder, the compass, the windmill or printing to the Chinese or other cultures.

However historian Peter Frankopan argues that influences, particularly trade, through the middle east & central Asia to China through the silk roads have been overlooked in traditional histories of the "rise of the west". He argues that the renaissance was funded with trade with the east (due to the demise of Byzantium at the hands of Venice and the 4th Crusade), and that the trade allowed ideas and technology to be shared with Europe. But the constant warfare and rivalry in Europe meant there was extreme evolutionary pressure for developing these ideas for military and economic advantage, and a desperate need to use them in expansion.

Disputes

While the concept of diffusion is well accepted in general, conjectures about the existence or the extent of diffusion in some specific contexts have been hotly disputed. An example of such disputes is the proposal by Thor Heyerdahl that similarities between the culture of Polynesia and the pre-Columbian civilizations of the Andes are due to diffusion from the latter to the former—a theory that currently has few supporters among professional anthropologists. Heyerdahl's theory of Polynesian origins has not gained acceptance among anthropologists (Trans-cultural diffusion).

UNIT-6

RURAL AND URBAN SETTLEMENTS AND ITS CLASSIFICATION

We all live in clusters of houses. You may call it a village, a town or a city, all are examples of human settlements. The study of human settlements is basic to human geography because the form of settlement in any particular region reflects human relationship with the environment. A human settlement is defined as a place inhabited more or less permanently. The houses may be designed or redesigned, buildings may be altered, functions may change but settlement continues in time and space. There may be some settlements which are temporary and are occupied for short periods, may be a season. It is widely accepted that settlements can be differentiated in terms of rural and urban, but there is no consensus on what exactly defines a village or a town. Although population size is an important criterion, it is not a universal criterion since many villages in densely populated countries of India and China have population exceeding that of some towns of Western Europe and United States.

Types of Rural Settlement

Settlements may also be classified by their shape, patterns types. The major types classified by shape are: (i) Compact or Nucleated settlements: These settlements are those in which large number of houses are built very close to each other. Such settlements develop along river valleys and in fertile plains. Communities are closely knit and share common occupations. (ii) Dispersed Settlements: In these settlements, houses are spaced far apart and often interspersed with fields. A cultural feature such as a place of worship or a market, binds the settlement together. Rural settlements are most closely and directly related to land. They are dominated by primary activities such as agriculture, animal husbandary, fishing etc. The settlements size is relatively small. Some factors affecting the location of rural settlements are : Water Supply Usually rural settlements are located near water bodies such as rivers, lakes, and springs where water can be easily obtained. Sometimes the need for water drives people to settle in otherwise disadvantaged sites such as islands surrounded by swamps or low lying river banks. Most water based 'wet point' settlements have many advantages such as water for drinking, cooking and washing. Rivers and lakes can be used to irrigate farm land. Water bodies also have fish which can be caught for diet and navigable rivers and lakes can be used for transportation. Land People choose to settle near fertile lands suitable for agriculture. In Europe villages grew up near rolling country avoiding swampy, low lying land while people in south east Asia chose to live near low lying river valleys and coastal plains suited for wet rice cultivation. Early settlers chose plain areas with fertile soils. Upland which is not prone to flooding was chosen to prevent damage to houses and loss of life. Thus, in low lying river basins people chose to settle on terraces and levees which are "dry points". In tropical countries people build their houses on stilts near marshy lands to protect themselves from flood, insects and animal pests. Building Material The availability of building materials- wood, stone near settlements is another advantage. Early villages were built in forest clearings where wood was plentiful. Defence During the times of political instability, war, hostility of neighbouring groups villages were built on defensive hills and islands. In Nigeria, upstanding inselbergs formed good defensive sites. In India most of the forts are located on higher grounds or hills. Planned Settlements Sites that are not spontaneously chosen by villagers themselves, planned settlements are constructed by governments by providing shelter, water and other infrastructures on acquired lands. The scheme of villagisation in Ethiopia and the canal colonies in Indira Gandhi canal command area in India are some good examples. Rural Settlement Patterns Patterns of rural settlements reflect the way the houses are sited in relation to each other. The site of the village, the surrounding topography and terrain influence the shape and size of a village. Rural settlements may be classified on the basis of a number of criteria: (i) On the basis of setting: The main types are plain villages, plateau villages, coastal villages, forest villages and desert villages. (ii) On the basis of functions: There may be farming villages, fishermen's villages, lumberjack villages,

pastoral villages etc. (iii) On the basis of forms or shapes of the settlements: These may be a number of geometrical forms and shapes such as Linear, rectangular, circular star like, T-shaped village, double village, cross-shaped village etc. (a) *Linear pattern*: In such settlements houses are located along a road, railway line, river, canal edge of a valley or along a levee. (b) *Rectangular pattern*: Such patterns of rural settlements are found in plain areas or wide inter montane valleys. The roads are rectangular and cut each other at right angles. In loess areas of China, cave dwellings were important and African Savanna's building materials were mud bricks and the Eskimos, in polar regions, use ice blocks to construct igloos. (c) *Circular pattern*: Circular villages develop around lakes, tanks and sometimes the village is planned in such a way that the central part remains open and is used for keeping the animals to protect them from wild animals. (d) *Star like pattern*: Where several roads converge, star shaped settlements develop by the houses built along the roads. (e) *T-shaped, Y-shaped, Cross-shaped or cruciform settlements*: T-shaped settlements develop at tri-junctions of the roads while Y-shaped settlements emerge as the places where two roads converge on the third one and houses are built along these roads. Cruciform settlements develop on the cross-roads and houses extend in all the four direction. (f) *Double village*: These settlements extend on both sides of a river where there is a bridge or a ferry.

Urban Settlements

Rapid urban growth is a recent phenomenon. Until recent times, few settlements reached the population size of more than a few thousand inhabitants. The first urban settlement to reach a population of one million was the city of London by around. A.D. 1810 By 1982 approximately 175 cities in the world had crossed the one million population mark. Presently 48 per cent of the world's population lives in urban settlements compared to only 3 per cent in the year 1800

Classification of Urban Settlements

Urban settlements are classified on the basis of following criteria:

Population Size

It is an important criteria used by most countries to define urban areas. The lower limit of the population size for a settlement to be designated as urban is 1,500 in Colombia, 2,000 in Argentina and Portugal, 2,500 in U.S.A. and Thailand, 5,000 in India and 30,000 in Japan. Besides the size of population, density of 400 persons per sq km and share of non-agricultural workers are taken into consideration in India. Countries with low density of population may choose a lower number as the cut-off figure compared to densely populated countries. In Denmark, Sweden and Finland, all places with a population size of 250 persons are called urban. The minimum population for a city is 300 in Iceland, whereas in Canada and Venezuela, it is 1,000 persons.

Occupational Structure

In some countries, such as India, the major economic activities in addition to the size of the population in designating a settlement as urban are also taken as a criterion. Similarly, in Italy, a settlement is called urban, if more than 50 per cent of its economically productive population is engaged in non-agricultural pursuits. India has set this criterion at 75 per cent.

Administration

The administrative setup is a criterion for classifying a settlement as urban in some countries. For example, in India, a settlement of any size is classified as urban, if it has a municipality, Cantonment Board or Notified Area Council. Similarly, in Latin American countries, such as Brazil and Bolivia, any administrative centre is considered urban irrespective of its population size.

Location

Location of urban centres is examined with reference to their function. For example, the sitting requirements of a holiday resort are quite different from that of an industrial town, a military centre or a seaport. Strategic towns require sites offering natural defence; mining towns require the presence of economically valuable minerals; industrial towns generally need local energy supplies or raw materials; tourist centres require attractive scenery, or a marine beach, a spring with medicinal water or historical relics, ports require a harbour etc. Locations of the earliest urban settlements were based on the availability of water, building materials and fertile land. Today, while these considerations still remain valid, modern technology plays a significant role in locating urban settlements far away from the source of these materials. Piped water can be supplied to a distant settlement, building material can be transported from long distances. Apart from site, the situation plays an important role in the expansion of towns. The urban centres which are located close to an important trade route have experienced rapid development.

Classification of Towns on The Basis of Forms

An urban settlement may be linear, square, star or crescent shaped. In fact, the form of the settlement, architecture and style of buildings and other structures are an outcome of its historical and cultural traditions. Towns and cities of developed and developing countries reflect marked differences in planning and development. While most cities in developed countries are planned, most urban settlements of developing countries have evolved historically with irregular shapes. For example, Chandigarh and Canberra are planned cities, while smaller town in India have evolved historically from walled cities to large urban sprawls. Types of Urban Settlements Depending on the size and the services available and functions rendered, urban centres are designated as town, city, million city, conurbation, megalopolis. Town The concept of 'town' can best be understood with reference to 'village'. Population size is not the only criterion. Functional contrasts between towns and villages may not always be clear cut, but specific functions such as, manufacturing, retail and wholesale trade, and professional services exist in towns.

Types of Urban Settlements

City

A city may be regarded as a leading town, which has outstripped its local or regional rivals. In the words of Lewis Mumford, "the city is in fact the physical form of the highest and most complex type of associative life". Cities are much larger than towns and have a greater number of economic functions. They tend to have transport terminals, major financial institutions and regional administrative offices. When the population crosses the one million mark it is designated as a million city.

Conurbation

The term conurbation was coined by Patrick Geddes in 1915 and applied to a large area of urban development that resulted from the merging of originally separate towns or cities. Greater London, Manchester, Chicago and Tokyo are examples. Can you find out an example from India?

Megalopolis

This Greek word meaning “great city”, was popularised by Jean Gottman (1957) and as union of conurbations. The urban landscape stretching from Boston to Washington in U.S.A. is the best known example of a megalopolis.

Million Cities

The number of million cities in the world has been increasing as never before. London reached the million mark in 1800, followed by Paris in 1850, New York in 1860, and by 1950 there were around 80 such cities. The rate of increase in the number of million cities has been three-fold in every three decades – around 160 in 1975 to around 438 in 2005 (NCERT- Human Settlement; Unit IV; Chapter 10).

UNIT-7

HUMAN DEVELOPMENT INDEX

The **Human Development Index (HDI)** is a statistic composite index of life expectancy, education, and per capita income indicators, which are used to rank countries into four tiers of human development. A country scores a higher HDI when the lifespan is higher, the education level is higher, and the gross national income GNI (PPP) per capita is higher. It was developed by Pakistani economist Mahbub ul Haq, with help from Gustav Ranis of Yale University and Meghnad Desai of the London School of Economics, and was further used to measure a country's development by the United Nations Development Program (UNDP)'s Human Development Report Office.

The 2010 Human Development Report introduced an **Inequality-adjusted Human Development Index (IHDI)**. While the simple HDI remains useful, it stated that "the IHDI is the actual level of human development (accounting for inequality)", and "the HDI can be viewed as an index of 'potential' human development (or the maximum IHDI that could be achieved if there were no inequality)". The index does not take into account several factors, such as the net wealth per capita or the relative quality of goods in a country. This situation tends to lower the ranking for some of the most advanced countries, such as the G7 members and others.

The index is based on the human development approach, developed by Amartya Sen, often framed in terms of whether people are **able to "be" and "do"** desirable things in life. Examples include—Being: well fed, sheltered, healthy; Doings: work, education, voting, participating in community life. The freedom of choice is central—someone choosing to be hungry (as during a religious fast) is quite different from someone who is hungry because they cannot afford to buy food, or because the country is in a famine.

Origins

The origins of the HDI are found in the annual Human Development Reports produced by the Human Development Report Office of the United Nations Development Programme (UNDP). These were devised and launched by Pakistani economist Mahbub ul Haq in 1990, and had the explicit purpose "to shift the focus of development economics from national income accounting to people-centered policies". To produce the Human Development Reports, Mahbub ul Haq formed a group of development economists including Paul Streeten, Frances Stewart, Gustav Ranis, Keith Griffin, Sudhir Anand, and Meghnad Desai. Nobel laureate Amartya Sen utilized Haq's work in his own work on human capabilities. Haq believed that a simple composite measure of human development was needed to convince the public, academics, and politicians that they can and should evaluate development not only by economic advances but also improvements in human well-being.

Dimensions and calculation

New method (2010 Index onwards)

Published on 4 November 2010 (and updated on 10 June 2011), the 2010 Human Development Report calculated the HDI combining three dimensions:

- A long and healthy life: Life expectancy at birth
- Education index: Mean years of schooling and Expected years of schooling

- A decent standard of living: GNI per capita (PPP US\$)

In its 2010 Human Development Report, the UNDP began using a new method of calculating the HDI. The following three indices are used:

$$1. \text{ Life Expectancy Index (LEI)} = \frac{\text{LE} - 20}{85 - 20}$$

LEI is 1 when Life expectancy at birth is 85 and 0 when Life expectancy at birth is 20.

$$2. \text{ Education Index (EI)} = \frac{\text{MYSI} + \text{EYSI}}{2}$$

$$2.1 \text{ Mean Years of Schooling Index (MYSI)} = \frac{\text{MYS}}{15}$$

Fifteen is the projected maximum of this indicator for 2025.

$$2.2 \text{ Expected Years of Schooling Index (EYSI)} = \frac{\text{EYS}}{18}$$

Eighteen is equivalent to achieving a master's degree in most countries.

$$3. \text{ Income Index (II)} = \frac{\ln(\text{GNIpc}) - \ln(100)}{\ln(75,000) - \ln(100)}$$

Income Index (II) is 1 when GNI per capita is \$75,000 and 0 when GNI per capita is \$100.

Finally, the HDI is the geometric mean of the previous three normalized indices:

$$\text{HDI} = \sqrt[3]{\text{LEI} \cdot \text{EI} \cdot \text{II}}$$

LE: Life expectancy at birth

MYS: Mean years of schooling (i.e. years that a person aged 25 or older has spent in formal education) EYS: Expected years of schooling (i.e. total expected years of schooling for children under

18 years of age)

GNIpc: Gross national income at purchasing power parity per capita

Old method (before 2010 Index)

- The HDI combined three dimensions last used in its 2009 Report:
- Life expectancy at birth, as an index of population health and longevity to HDI
- Knowledge and education, as measured by the adult literacy rate (with two-thirds weighting) and the combined primary, secondary, and tertiary gross enrollment ratio (with one-third weighting).

- Standard of living, as indicated by the natural logarithm of gross domestic product per capita at purchasing power parity.

This methodology was used by the UNDP until their 2011 report.

The formula defining the HDI is promulgated by the United Nations Development Programme (UNDP). In general, to transform a raw variable, say x , into a unit-free index between 0 and 1 (which allows different indices to be added together), the following formula is used:

$$x \text{ index} = \frac{x-a}{b-a}$$

where a and b are the lowest and highest values the variable x can attain, respectively.

The Human Development Index (HDI) then represents the uniformly weighted sum with $\frac{1}{3}$ contributed by each of the following factor indices:

$$\text{Life Expectancy Index} = \frac{LE-25}{85-25}$$

$$\text{Education Index} = \frac{2}{3} \times ALI + \frac{1}{3} \times GEI$$

$$\text{Adult Literacy Index (ALI)} = \frac{ALR-0}{100-0}$$

$$\text{Gross Enrolment Index (GEI)} = \frac{CGER-0}{100-0}$$

$$\text{GDP} = \frac{\text{Log (GDPpc)} - \text{Log}(100)}{\text{Log (40000)} - \text{Log}(100)}$$

Other organizations/companies may include other factors, such as infant mortality, which produces a different HDI.

Criticism

The Human Development Index has been criticized on a number of grounds, including alleged lack of consideration of technological development or contributions to the human civilization, focusing exclusively on national performance and ranking, lack of attention to development from a global perspective, measurement error of the underlying statistics, and on the UNDP's changes in formula which can lead to severe misclassification in the categorisation of 'low', 'medium', 'high' or 'very high' human development countries.

Sources of data error

Economists Hendrik Wolff, Howard Chong and Maximilian Auffhammer discuss the HDI from the perspective of data error in the underlying health, education and income statistics used to construct the HDI. They identified three sources of data error which are due to (i) data updating, (ii) formula revisions and (iii) thresholds to classify a country's development status and conclude that 11%, 21% and 34% of all countries can be interpreted as currently misclassified in the development bins due to the three sources of data error, respectively. The authors suggest that the United Nations should discontinue the practice of classifying countries into development bins because: the cut-off values seem arbitrary, can provide incentives for strategic behavior in reporting official statistics, and have

the potential to misguide politicians, investors, charity donors and the public who use the HDI at large.

In 2010, the UNDP reacted to the criticism and updated the thresholds to classify nations as low, medium, and high human development countries. In a comment to *The Economist* in early January 2011, the Human Development Report Office responded to a 6 January 2011 article in the magazine which discusses the Wolff *et al.* paper. The Human Development Report Office states that they undertook a systematic revision of the methods used for the calculation of the HDI, and that the new methodology directly addresses the critique by Wolff *et al.* in that it generates a system for continuously updating the human-development categories whenever formula or data revisions take place.

In 2013, Salvatore Monni and Alessandro Spaventa emphasized that in the debate of GDP versus HDI, it is often forgotten that these are both external indicators that prioritize different benchmarks upon which the quantification of societal welfare can be predicated. The larger question is whether it is possible to shift the focus of policy from a battle between competing paradigms to a mechanism for eliciting information on well-being directly from the population (Human Development Index).

UNIT-8

SUSTAINABLE DEVELOPMENT

Sustainable development is the organizing principle for meeting human development goals while at the same time sustaining the ability of natural systems to provide the natural resources and ecosystem services upon which the economy and society depend. The desired result is a state of society where living conditions and resource use continue to meet human needs without undermining the integrity and stability of the natural system. Sustainable development can be classified as development that meets the needs of the present without compromising the ability of future generations.

While the modern concept of sustainable development is derived mostly from the 1987 Brundtland Report, it is also rooted in earlier ideas about sustainable forest management and twentieth century environmental concerns. As the concept developed, it has shifted to focus more on economic development, social development and environmental protection for future generations. It has been suggested that "the term 'sustainability' should be viewed as humanity's target goal of human-ecosystem equilibrium (homeostasis), while 'sustainable development' refers to the holistic approach and temporal processes that lead us to the end point of sustainability". Modern economies are endeavouring to reconcile ambitious economic development and obligations of preserving natural resources and ecosystems, as the two are usually seen as of conflicting nature. Instead of holding climate change commitments and other sustainability measures as a drag to economic development, turning and leveraging them into market opportunities will do greater good. The economic development brought by such organized principles and practices in an economy is called Managed Sustainable Development (MSD)

The concept of sustainable development has been—and still is—subject to criticism, including the question of what is to be sustained in sustainable development. It has been argued that there is no such thing as a sustainable use of a non-renewable resource, since any positive rate of exploitation will eventually lead to the exhaustion of earth's finite stock; this perspective renders the Industrial Revolution as a whole unsustainable. It has also been argued that the meaning of the concept has opportunistically been stretched from 'conservation management' to 'economic development', and that the Brundtland Report promoted nothing but a business as usual strategy for world development, with an ambiguous and insubstantial concept attached as a public relations slogan (see below)

History

Sustainability can be defined as the practice of maintaining processes of productivity indefinitely—natural or human made—by replacing resources used with resources of equal or greater value without degrading or endangering natural biotic systems. Sustainable development ties together concern for the carrying capacity of natural systems with the social, political, and economic challenges faced by humanity. Sustainability science is the study of the concepts of sustainable development and environmental science. There is an additional focus on the present generations' responsibility to regenerate, maintain and improve planetary resources for use by future generations

Sustainable development has its roots in ideas about sustainable forest management which were developed in Europe during the 17th and 18th centuries. In response to a growing awareness of the depletion of timber resources in England, John Evelyn argued that "sowing and planting of trees had to be regarded as a national duty of every landowner, in order to stop the destructive over-exploitation of natural resources" in his 1662 essay *Sylva*. In 1713 Hans Carl von Carlowitz, a senior mining administrator in the service of Elector Frederick Augustus I of Saxony published *Sylvicultura oeconomica*, a 400-page work on forestry. Building upon the ideas of Evelyn and French

minister Jean-Baptiste Colbert, von Carlowitz developed the concept of managing forests for sustained yield. His work influenced others, including Alexander von Humboldt and Georg Ludwig Hartig, eventually leading to the development of a science of forestry. This in turn influenced people like Gifford Pinchot, first head of the US Forest Service, whose approach to forest management was driven by the idea of wise use of resources, and Aldo Leopold whose land ethic was influential in the development of the environmental movement in the 1960s

Following the publication of Rachel Carson's *Silent Spring* in 1962, the developing environmental movement drew attention to the relationship between economic growth and development and environmental degradation. Kenneth E. Boulding in his influential 1966 essay *The Economics of the Coming Spaceship Earth* identified the need for the economic system to fit itself to the ecological system with its limited pools of resources. One of the first uses of the term sustainable in the contemporary sense was by the Club of Rome in 1972 in its classic report on the *Limits to Growth*, written by a group of scientists led by Dennis and Donella Meadows of the Massachusetts Institute of Technology. Describing the desirable "state of global equilibrium", the authors wrote: "We are searching for a model output that represents a world system that is sustainable without sudden and uncontrolled collapse and capable of satisfying the basic material requirements of all of its people

Following the Club of Rome report, an MIT research group prepared ten days of hearings on "Growth and Its Implication for the Future" (Roundtable Press, 1973) for the US Congress, the first hearings ever held on sustainable development. William Flynn Martin, David Dodson Gray, and Elizabeth Gray prepared the hearings under the Chairmanship of Congressman John Dingell.

In 1980 the International Union for the Conservation of Nature published a world conservation strategy that included one of the first references to sustainable development as a global priority and introduced the term "sustainable development". Two years later, the United Nations World Charter for Nature raised five principles of conservation by which human conduct affecting nature is to be guided and judged. In 1987 the United Nations World Commission on Environment and Development released the report *Our Common Future*, commonly called the Brundtland Report. The report included what is now one of the most widely recognised definitions of sustainable development.

Since the Brundtland Report, the concept of sustainable development has developed beyond the initial intergenerational framework to focus more on the goal of "socially inclusive and environmentally sustainable economic growth". In 1992, the UN Conference on Environment and Development published the Earth Charter, which outlines the building of a just, sustainable, and peaceful global society in the 21st century. The action plan Agenda 21 for sustainable development identified information, integration, and participation as key building blocks to help countries achieve development that recognises these interdependent pillars. It emphasises that in sustainable development everyone is a user and provider of information. It stresses the need to change from old sector-centered ways of doing business to new approaches that involve cross-sectoral co-ordination and the integration of environmental and social concerns into all development processes. Furthermore, Agenda 21 emphasises that broad public participation in decision making is a fundamental prerequisite for achieving sustainable development

Under the principles of the United Nations Charter the Millennium Declaration identified principles and treaties on sustainable development, including economic development, social development and environmental protection. Broadly defined, sustainable development is a systems approach to growth and development and to manage natural, produced, and social capital for the

welfare of their own and future generations. The term sustainable development as used by the United Nations incorporates both issues associated with land development and broader issues of human development such as education, public health, and standard of living.

A 2013 study concluded that sustainability reporting should be reframed through the lens of four interconnected domains: ecology, economics, politics and culture

Sustainable Development Goals (SDGs)

In September 2015, the United Nations General Assembly formally adopted the "universal, integrated and transformative" 2030 Agenda for Sustainable Development, a set of 17 Sustainable Development Goals(SDGs). The goals are to be implemented and achieved in every country from the year 2016 to 2030.

Education for Sustainable Development (ESD)

Education for Sustainable Development (ESD) is defined as education that encourages changes in knowledge, skills, values and attitudes to enable a more sustainable and equitable society. ESD aims to empower and equip current and future generations to meet their needs using a balanced and integrated approach to the economic, social and environmental dimensions of sustainable development

Concept

The concept of ESD was born from the need for education to address the growing environmental challenges facing the planet. In order to do this, education must change to provide the knowledge, skills, values and attitudes that empower learners to contribute to sustainable development. At the same time, education must be strengthened in all agendas, programmes, and activities that promote sustainable development. Sustainable development must be integrated into education and education must be integrated into sustainable development. ESD is holistic and transformational education and concerns learning content and outcomes, pedagogy and the learning environment (UNESCO, 2014). With regards to learning content such as curricula, the complex sustainability challenges facing societies cut across boundaries and multiple thematic areas. Education must therefore address key issues such as climate change, poverty and sustainable production. ESD promotes the integration of these critical sustainability issues in local and global contexts into the curriculum to prepare learners to understand and respond to the changing world. ESD aims to produce learning outcomes that include core competencies such as critical and systemic thinking, collaborative decision-making, and taking responsibility for the present and future generations. In order to deliver such diverse and evolving issues, ESD uses innovative pedagogy, encouraging teaching and learning in an interactive, learner-centered way that enables exploratory, action-oriented and transformative learning. Learners are enabled to think critically and systematically develop values and attitudes for a sustainable future. Since traditional single-directional delivery of knowledge is not sufficient to inspire learners to take action as responsible citizens, ESD entails rethinking the learning environment, physical and virtual. ESD applies to all levels of formal, non-formal and informal education as an integral part of lifelong learning. The learning environment itself must adapt and apply a whole-institution approach to embed the philosophy of sustainable development. Building the capacity of educators and policy support at international, regional, national and local levels helps drive changes in learning institutions. Empowered youth and local communities interacting with education institutions become key actors in advancing sustainable development.

UN Decade for Sustainable Development

The launch of the UN Decade of Education for Sustainable Development (2005-2014) started a global movement to reorient education to address the challenges of sustainable development. Building on the achievement of the Decade, stated in the Aichi-Nagoya Declaration on ESD, UNESCO endorsed the Global Action Programme on ESD (GAP) in the 37th session of its General Conference. Acknowledged by UN General Assembly Resolution A/RES/69/211 and launched at the UNESCO World Conference on ESD in 2014, the GAP aims to scale-up actions and good practices. UNESCO has a major role, along with its partners, in bringing about key achievements to ensure the principles of ESD are promoted through formal, non-formal and informal education.

International recognition of ESD as the key enabler for sustainable development is growing steadily. The role of ESD was recognized in three major UN summits on sustainable development: the 1992 UN Conference on Environment and Development (UNCED) in Rio de Janeiro, Brazil; the 2002 World Summit on Sustainable Development (WSSD) in Johannesburg, South Africa; and the 2012 UN Conference on Sustainable Development (UNCSD) in Rio de Janeiro. Other key global agreements such as the Paris Agreement (Article 12) also recognize the importance of ESD. Today, ESD is arguably at the heart of the 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals (SDGs) (United Nations, 2015). The SDGs recognize that all countries must stimulate action in the following key areas - people, planet, prosperity, peace and partnership - in order to tackle the global challenges that are crucial for the survival of humanity. ESD is explicitly mentioned in Target 4.7 of SDG4, which aims to ensure that all learners acquire the knowledge and skills needed to promote sustainable development and is understood as an important means to achieve all the other 16 SDGs (UNESCO, 2017)

Domains

Sustainable development, or sustainability, has been described in terms of three spheres, dimensions, domains or pillars, i.e. the environment, the economy and society. The three-sphere framework was initially proposed by the economist René Passet in 1979. It has also been worded as "economic, environmental and social" or "ecology, economy and equity". This has been expanded by some authors to include a fourth pillar of culture, institutions or governance, or alternatively reconfigured as four domains of the social - ecology, economics, politics and culture, thus bringing economics back inside the social, and treating ecology as the intersection of the social and the natural.

Environmental (or ecological)

The ecological stability of human settlements is part of the relationship between humans and their natural, social and built environments. Also termed human ecology, this broadens the focus of sustainable development to include the domain of human health. Fundamental human needs such as the availability and quality of air, water, food and shelter are also the ecological foundations for sustainable development; addressing public health risk through investments in ecosystem services can be a powerful and transformative force for sustainable development which, in this sense, extends to all species.

Environmental sustainability concerns the natural environment and how it endures and remains diverse and productive. Since natural resources are derived from the environment, the state of air, water, and the climate are of particular concern. The IPCC Fifth Assessment Report outlines current knowledge about scientific, technical and socio-economic information concerning climate change, and lists options for adaptation and mitigation. Environmental sustainability requires society to design activities to meet human needs while preserving the life support systems of the planet. This, for example, entails using water sustainably, utilizing renewable energy, and sustainable material supplies (e.g. harvesting wood from forests at a rate that maintains the biomass and biodiversity).

An unsustainable situation occurs when natural capital (the sum total of nature's resources) is used up faster than it can be replenished. Sustainability requires that human activity only uses nature's resources at a rate at which they can be replenished naturally. Inherently the concept of sustainable development is intertwined with the concept of carrying capacity. Theoretically, the long-term result of environmental degradation is the inability to sustain human life. Such degradation on a global scale should imply an increase in human death rate until population falls to what the degraded environment can support. If the degradation continues beyond a certain tipping point or critical threshold it would lead to eventual extinction for humanity.

Consumption of natural resources	State of environment	Sustainability
More than nature's ability to replenish	Environmental degradation	Not sustainable
Equal to nature's ability to replenish	Environmental equilibrium	Steady state economy
Less than nature's ability to replenish	Environmental renewal	Environmentally sustainable

Integral elements for a sustainable development are research and innovation activities. A telling example is the European environmental research and innovation policy, which aims at defining and implementing a transformative agenda to greening the economy and the society as a whole so to achieve a truly sustainable development. Research and innovation in Europe is financially supported by the programme Horizon 2020, which is also open to participation worldwide. A promising direction towards sustainable development is to design systems that are flexible and reversible.

Pollution of the public resources is really not a different action, it just is a reverse tragedy of the commons, in that instead of taking something out, something is put into the commons. When the costs of polluting the commons are not calculated into the cost of the items consumed, then it becomes only natural to pollute, as the cost of pollution is external to the cost of the goods produced and the cost of cleaning the waste before it is discharged exceeds the cost of releasing the waste directly into the commons. So, the only way to solve this problem is by protecting the ecology of the commons by making it, through taxes or fines, more costly to release the waste directly into the commons than would be the cost of cleaning the waste before discharge.

So, one can try to appeal to the ethics of the situation by doing the right thing as an individual, but in the absence of any direct consequences, the individual will tend to do what is best for the person and not what is best for the common good of the public. Once again, this issue needs to be addressed. Because, left unaddressed, the development of the commonly owned property will become impossible to achieve in a sustainable way. So, this topic is central to the understanding of creating a sustainable situation from the management of the public resources that are used for personal use.

Agriculture

Sustainable agriculture consists of environment friendly methods of farming that allow the production of crops or livestock without damage to human or natural systems. It involves preventing adverse effects to soil, water, biodiversity, surrounding or downstream resources—as well as to those working or living on the farm or in neighboring areas. The concept of sustainable agriculture extends intergenerationally, passing on a conserved or improved natural resource, biotic, and economic base rather than one which has been depleted or polluted. Elements of sustainable agriculture

include permaculture, agroforestry, mixed farming, multiple cropping, and crop rotation. It involves agricultural methods that do not undermine the environment, smart farming technologies that enhance a quality environment for humans to thrive and reclaiming and transforming deserts into farmlands(Herman Daly, 2017).

Numerous sustainability standards and certification systems exist, including organic certification, Rainforest Alliance, Fair Trade, UTZ Certified, Bird Friendly, and the Common Code for the Coffee Community (4C).

Economics

It has been suggested that because of rural poverty and overexploitation, environmental resources should be treated as important economic assets, called natural capital. Economic development has traditionally required a growth in the gross domestic product. This model of unlimited personal and GDP growth may be over. Sustainable development may involve improvements in the quality of life for many but may necessitate a decrease in resource consumption. According to ecological economist Malte Faber, ecological economics is defined by its focus on nature, justice, and time. Issues of intergenerational equity, irreversibility of environmental change, uncertainty of long-term outcomes, and sustainable development guide ecological economic analysis and valuation.

As early as the 1970s, the concept of sustainability was used to describe an economy "in equilibrium with basic ecological support systems". Scientists in many fields have highlighted *The Limits to Growth*, and economists have presented alternatives, for example a 'steady-state economy', to address concerns over the impacts of expanding human development on the planet. In 1987 the economist Edward Barbier published the study *The Concept of Sustainable Economic Development*, where he recognised that goals of environmental conservation and economic development are not conflicting and can be reinforcing each other.

A World Bank study from 1999 concluded that based on the theory of genuine savings, policymakers have many possible interventions to increase sustainability, in macroeconomics or purely environmental. Several studies have noted that efficient policies for renewable energy and pollution are compatible with increasing human welfare, eventually reaching a golden-rule steady state.

The study, *Interpreting Sustainability in Economic Terms*, found three pillars of sustainable development, interlinkage, intergenerational equity, and dynamic efficiency.

But Gilbert Rist points out that the World Bank has twisted the notion of sustainable development to prove that economic development need not be deterred in the interest of preserving the ecosystem. He writes: "From this angle, 'sustainable development' looks like a cover-up operation. ... The thing that is meant to be sustained is really 'development', not the tolerance capacity of the ecosystem or of human societies."

The World Bank, a leading producer of environmental knowledge, continues to advocate the win-win prospects for economic growth and ecological stability even as its economists express their doubts. Herman Daly, an economist for the Bank from 1988 to 1994, writes:

When authors of *WDR '92* [the highly influential 1992 *World Development Report* that featured the environment] were drafting the report, they called me asking for examples of "win-win" strategies in my work. What could I say? None exists in that pure form; there are trade-offs, not "win-wins." But they want to see a world of "win-wins" based on articles of faith, not fact. I wanted to contribute because *WDRs* are important in the Bank, [because] task managers read [them] to find philosophical justification for their latest round of projects. But they did not want to hear about how things really are, or what I find in my work..."

A meta review in 2002 looked at environmental and economic valuations and found a lack of "sustainability policies". A study in 2004 asked if we consume too much. A study concluded in 2007 that knowledge, manufactured and human capital (health and education) has not compensated for the degradation of natural capital in many parts of the world. It has been suggested that intergenerational equity can be incorporated into a sustainable development and decision making, as has become common in economic valuations of climate economics. A meta review in 2009 identified conditions for a strong case to act on climate change, and called for more work to fully account of the relevant economics and how it affects human welfare. According to free-market environmentalist John Baden "the improvement of environment quality depends on the market economy and the existence of legitimate and protected property rights". They enable the effective practice of personal responsibility and the development of mechanisms to protect the environment. The State can in this context "create conditions which encourage the people to save the environment".

Misum, Mistra Center for Sustainable Markets, based at Stockholm School of Economics, aims to provide policy research and advice to Swedish and international actors on Sustainable Markets. Misum is a cross-disciplinary and multi-stakeholder knowledge center dedicated to sustainability and sustainable markets and contains three research platforms: Sustainability in Financial Markets (Mistra Financial Systems), Sustainability in Production and Consumption and Sustainable Socio-Economic Development.

Environmental economics

The total environment includes not just the biosphere of earth, air, and water, but also human interactions with these things, with nature, and what humans have created as their surroundings.

As countries around the world continue to advance economically, they put a strain on the ability of the natural environment to absorb the high level of pollutants that are created as a part of this economic growth. Therefore, solutions need to be found so that the economies of the world can continue to grow, but not at the expense of the public good. In the world of economics the amount of environmental quality must be considered as limited in supply and therefore is treated as a scarce resource. This is a resource to be protected. One common way to analyze possible outcomes of policy decisions on the scarce resource is to do a cost-benefit analysis. This type of analysis contrasts different options of resource allocation and, based on an evaluation of the expected courses of action and the consequences of these actions, the optimal way to do so in the light of different policy goals can be elicited.

Benefit-cost analysis basically can look at several ways of solving a problem and then assigning the best route for a solution, based on the set of consequences that would result from the further development of the individual courses of action, and then choosing the course of action that results in the least amount of damage to the expected outcome for the environmental quality that remains after that development or process takes place. Further complicating this analysis are the interrelationships of the various parts of the environment that might be impacted by the chosen course of action. Sometimes it is almost impossible to predict the various outcomes of a course of action, due to the

unexpected consequences and the amount of unknowns that are not accounted for in the benefit-cost analysis.

Energy

Sustainable energy is clean and can be used over a long period of time. Unlike fossil fuels and biofuels that provide the bulk of the world's energy, renewable energy sources like hydroelectric, solar and wind energy produce far less pollution. Solar energy is commonly used on public parking meters, street lights and the roof of buildings. Wind power has expanded quickly, its share of worldwide electricity usage at the end of 2014 was 3.1%. Most of California's fossil fuel infrastructures are sited in or near low-income communities, and have traditionally suffered the most from California's fossil fuel energy system. These communities are historically left out during the decision-making process, and often end up with dirty power plants and other dirty energy projects that poison the air and harm the area. These toxicants are major contributors to health problems in the communities. As renewable energy becomes more common, fossil fuel infrastructures are replaced by renewables, providing better social equity to these communities. Overall, and in the long run, sustainable development in the field of energy is also deemed to contribute to economic sustainability and national security of communities, thus being increasingly encouraged through investment policies.

Manufacturing

Technology

One of the core concepts in sustainable development is that technology can be used to assist people meet their developmental needs. Technology to meet these sustainable development needs is often referred to as appropriate technology, which is an ideological movement (and its manifestations) originally articulated as intermediate technology by the economist E. F. Schumacher in his influential work, *Small is Beautiful*, and now covers a wide range of technologies. Both Schumacher and many modern-day proponents of appropriate technology also emphasise the technology as people-centered. Today appropriate technology is often developed using open source principles, which have led to open-source appropriate technology (OSAT) and thus many of the plans of the technology can be freely found on the Internet. OSAT has been proposed as a new model of enabling innovation for sustainable development.

Transport

Transportation is a large contributor to greenhouse gas emissions. It is said that one-third of all gasses produced are due to transportation. Motorized transport also releases exhaust fumes that contain particulate matter which is hazardous to human health and a contributor to climate change.

Sustainable transport has many social and economic benefits that can accelerate local sustainable development. According to a series of reports by the Low Emission Development Strategies Global Partnership (LEDS GP), sustainable transport can help create jobs, improve commuter safety through investment in bicycle lanes and pedestrian pathways, make access to employment and social opportunities more affordable and efficient. It also offers a practical opportunity to save people's time and household income as well as government budgets, making investment in sustainable transport a 'win-win' opportunity.

Some Western countries are making transportation more sustainable in both long-term and short-term implementations. An example is the modification in available transportation in Freiburg, Germany. The city has implemented extensive methods of public transportation, cycling, and walking, along with large areas where cars are not allowed.

Since many Western countries are highly automobile-oriented, the main transit that people use is personal vehicles. About 80% of their travel involves cars. Therefore, California is one of the

highest greenhouse gas emitters in the United States. The federal government has to come up with some plans to reduce the total number of vehicle trips in order to lower greenhouse gases emission. Such as:

- Improve public transit through the provision of larger coverage area in order to provide more mobility and accessibility, new technology to provide a more reliable and responsive public transportation network.
- Encourage walking and biking through the provision of wider pedestrian pathway, bike share stations in downtowns, locate parking lots far from the shopping center, limit on street parking, slower traffic lane in downtown area.
- Increase the cost of car ownership and gas taxes through increased parking fees and tolls, encouraging people to drive more fuel efficient vehicles. This can produce a social equity problem, since lower income people usually drive older vehicles with lower fuel efficiency. Government can use the extra revenue collected from taxes and tolls to improve public transportation and benefit poor communities.

Other states and nations have built efforts to translate knowledge in behavioral economics into evidence-based sustainable transportation policies.

Business

The most broadly accepted criterion for corporate sustainability constitutes a firm's efficient use of natural capital. This eco-efficiency is usually calculated as the economic value added by a firm in relation to its aggregated ecological impact. This idea has been popularised by the World Business Council for Sustainable Development (WBCSD) under the following definition: "Eco-efficiency is achieved by the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life-cycle to a level at least in line with the earth's carrying capacity" (DeSimone and Popoff, 1997: 47).

Similar to the eco-efficiency concept but so far less explored is the second criterion for corporate sustainability. Socio-efficiency describes the relation between a firm's value added and its social impact. Whereas, it can be assumed that most corporate impacts on the environment are negative (apart from rare exceptions such as the planting of trees) this is not true for social impacts. These can be either positive (e.g. corporate giving, creation of employment) or negative (e.g. work accidents, mobbing of employees, human rights abuses). Depending on the type of impact socio-efficiency thus either tries to minimise negative social impacts (i.e. accidents per value added) or maximise positive social impacts (i.e. donations per value added) in relation to the value added.

Both eco-efficiency and socio-efficiency are concerned primarily with increasing economic sustainability. In this process they instrumentalise both natural and social capital aiming to benefit from win-win situations. However, as Dyllick and Hockerts point out the business case alone will not be sufficient to realise sustainable development. They point towards eco-effectiveness, socio-effectiveness, sufficiency, and eco-equity as four criteria that need to be met if sustainable development is to be reached.

CASI Global, New York "CSR & Sustainability together lead to sustainable development. CSR as in corporate social responsibility is not what you do with your profits, but is the way you make profits. This means CSR is a part of every department of the company value chain and not a part of HR / independent department. Sustainability as in effects towards Human resources, Environment and Ecology has to be measured within each department of the company." <http://casiglobal.us/>

Income

At the present time, sustainable development can reduce poverty. Sustainable development reduces poverty through financial (among other things, a balanced budget), environmental (living conditions), and social (including equality of income) means.

Architecture

In sustainable architecture the recent movements of New Urbanism and New Classical architecture promote a sustainable approach towards construction that appreciates and develops smart growth, architectural tradition and classical design. This in contrast to modernist and International Style architecture, as well as opposing to solitary housing estates and suburban sprawl, with long commuting distances and large ecological footprints. Both trends started in the 1980s. (Sustainable architecture is predominantly relevant to the economics domain while architectural landscaping pertains more to the ecological domain.)

Politics

A study concluded that social indicators and, therefore, sustainable development indicators, are scientific constructs whose principal objective is to inform public policy-making. The International Institute for Sustainable Development has similarly developed a political policy framework, linked to a sustainability index for establishing measurable entities and metrics. The framework consists of six core areas, international trade and investment, economic policy, climate change and energy, measurement and assessment, natural resource management, and the role of communication technologies in sustainable development.

The United Nations Global Compact Cities Programme has defined sustainable political development in a way that broadens the usual definition beyond states and governance. The political is defined as the domain of practices and meanings associated with basic issues of social power as they pertain to the organisation, authorisation, legitimation and regulation of a social life held in common. This definition is in accord with the view that political change is important for responding to economic, ecological and cultural challenges. It also means that the politics of economic change can be addressed. They have listed seven subdomains of the domain of politics:

1. Organization and governance
2. Law and justice
3. Communication and critique
4. Representation and negotiation
5. Security and accord
6. Dialogue and reconciliation
7. Ethics and accountability

These accords with the Brundtland Commission emphasis on development that is guided by human rights principles.

Culture

Working with a different emphasis, some researchers and institutions have pointed out that a fourth dimension should be added to the dimensions of sustainable development, since the triple-bottom-line dimensions of economic, environmental and social do not seem to be enough to reflect the complexity of contemporary society. In this context, the Agenda 21 for culture and the United Cities and Local Governments (UCLG) Executive Bureau lead the preparation of the policy statement "Culture: Fourth Pillar of Sustainable Development", passed on 17 November 2010, in the framework of the World Summit of Local and Regional Leaders – 3rd World Congress of UCLG, held in Mexico City. This document inaugurates a new perspective and points to the relation between culture and sustainable development through a dual approach: developing a solid cultural policy and advocating a cultural dimension in all public policies. The Circles of Sustainability approach distinguishes the four domains of economic, ecological, political and cultural sustainability.

Other organizations have also supported the idea of a fourth domain of sustainable development. The Network of Excellence "Sustainable Development in a Diverse World", sponsored by the European Union, integrates multidisciplinary capacities and interprets cultural diversity as a key element of a new strategy for sustainable development. The Fourth Pillar of Sustainable Development Theory has been referenced by executive director of IMI Institute at UNESCO Vito Di Bari in his manifesto of art and architectural movement Neo-Futurism, whose name was inspired by the 1987 United Nations' report Our Common Future. The Circles of Sustainability approach used by Metropolis defines the (fourth) cultural domain as practices, discourses, and material expressions, which, over time, express continuities and discontinuities of social meaning.

Cultural Elements in Sustainable Development Frameworks

Recently, human-centered design and cultural collaboration have been popular frameworks for sustainable development in marginalized communities. These frameworks involve open dialogue which entails sharing, debating, and discussing, as well as holistic evaluation of the site of development. Especially when working on sustainable development in marginalized communities, cultural emphasis is a crucial factor in project decisions, since it largely affects aspects of their lives and traditions. Collaborators utilize articulation theory in co-designing. This allows for them to understand each other's thought process and their comprehension of the sustainable projects. By using the method of co-design, the beneficiaries' holistic needs are being considered. Final decisions and implementations are made with respect to socio-cultural and ecological factors.

Human Centered Design

The user-oriented framework relies heavily on user participation and user feedback in the planning process. Users are able to provide new perspective and ideas, which can be considered in a new round of improvements and changes. It is said that increased user participation in the design process can garner a more comprehensive understanding of the design issues, due to more contextual and emotional transparency between researcher and participant. A key element of human centered design is applied ethnography, which was a research method adopted from cultural anthropology. This research method requires researchers to be fully immersed in the observation so that implicit details are also recorded.

Life Cycle Analysis

Many communities express environmental concerns, so life cycle analysis is often conducted when assessing the sustainability of a product or prototype. The assessment is done in stages with meticulous cycles of planning, design, implementation, and evaluation. The decision to choose materials is heavily weighted on its longevity, renewability, and efficiency. These factors ensure that

researchers are conscious of community values that align with positive environmental, social, and economic impacts.

Themes

Progress

The United Nations Conference on Sustainable Development (UNCSD; also known as Rio 2012) was the third international conference on sustainable development, which aimed at reconciling the economic and environmental goals of the global community. An outcome of this conference was the development of the Sustainable Development Goals that aim to promote sustainable progress and eliminate inequalities around the world. However, few nations met the World Wide Fund for Nature's definition of sustainable development criteria established in 2006. Although some nations are more developed than others, all nations are constantly developing because each nation struggles with perpetuating disparities, inequalities and unequal access to fundamental rights and freedoms.

Measurement

In 2007 a report for the U.S. Environmental Protection Agency stated: "While much discussion and effort has gone into sustainability indicators, none of the resulting systems clearly tells us whether our society is sustainable. At best, they can tell us that we are heading in the wrong direction, or that our current activities are not sustainable. More often, they simply draw our attention to the existence of problems, doing little to tell us the origin of those problems and nothing to tell us how to solve them." Nevertheless, a majority of authors assume that a set of well defined and harmonised indicators is the only way to make sustainability tangible. Those indicators are expected to be identified and adjusted through empirical observations (trial and error).

The most common critiques are related to issues like data quality, comparability, objective function and the necessary resources. However a more general criticism is coming from the project management community: How can a sustainable development be achieved at global level if we cannot monitor it in any single project?

The Cuban-born researcher and entrepreneur Sonia Bueno suggests an alternative approach that is based upon the integral, long-term cost-benefit relationship as a measure and monitoring tool for the sustainability of every project, activity or enterprise. Furthermore, this concept aims to be a practical guideline towards sustainable development following the principle of conservation and increment of value rather than restricting the consumption of resources.

Reasonable qualifications of sustainability are seen U.S. Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED). This design incorporates some ecological, economic, and social elements. The goals presented by LEED design goals are sustainable sites, water efficiency, energy and atmospheric emission reduction, material and resources efficiency, and indoor environmental quality. Although amount of structures for sustainability development is many, these qualification has become a standard for sustainable building.

Recent research efforts created also the SDEWES Index to benchmark the performance of cities across aspects that are related to energy, water and environment systems. The SDEWES Index consists of 7 dimensions, 35 indicators, and close to 20 sub-indicators. It is currently applied to 58 cities.

Natural capital

The sustainable development debate is based on the assumption that societies need to manage three types of capital (economic, social, and natural), which may be non-substitutable and whose consumption might be irreversible. Leading ecological economist and steady-state theorist Herman Daly, for example, points to the fact that natural capital can not necessarily be substituted by economic capital. While it is possible that we can find ways to replace some natural resources, it is much more unlikely that they will ever be able to replace eco-system services, such as the protection provided by the ozone layer, or the climate stabilizing function of the Amazonian forest. In fact natural capital, social capital and economic capital are often complementarities. A further obstacle to substitutability lies also in the multi-functionality of many natural resources. Forests, for example, not only provide the raw material for paper (which can be substituted quite easily), but they also maintain biodiversity, regulate water flow, and absorb CO₂.

Another problem of natural and social capital deterioration lies in their partial irreversibility. The loss of biodiversity, for example, is often definitive. The same can be true for cultural diversity. For example, with globalisation advancing quickly the number of indigenous languages is dropping at alarming rates. Moreover, the depletion of natural and social capital may have non-linear consequences. Consumption of natural and social capital may have no observable impact until a certain threshold is reached. A lake can, for example, absorb nutrients for a long time while actually increasing its productivity. However, once a certain level of algae is reached lack of oxygen causes the lake's ecosystem to break down suddenly.

Business-as-usual

If the degradation of natural and social capital has such important consequence the question arises why action is not taken more systematically to alleviate it. Cohen and Winn point to four types of market failure as possible explanations: First, while the benefits of natural or social capital depletion can usually be privatised, the costs are often externalised (i.e. they are borne not by the party responsible but by society in general). Second, natural capital is often undervalued by society since we are not fully aware of the real cost of the depletion of natural capital. Information asymmetry is a third reason—often the link between cause and effect is obscured, making it difficult for actors to make informed choices. Cohen and Winn close with the realization that contrary to economic theory many firms are not perfect optimisers. They postulate that firms often do not optimise resource allocation because they are caught in a "business as usual" mentality.

Education

Education must be revisited in light of a renewed vision of sustainable human and social development that is both equitable and viable. This vision of sustainability must take into consideration the social, environmental and economic dimensions of human development and the various ways in which these relate to education: 'An empowering education is one that builds the human resources we need to be productive, to continue to learn, to solve problems, to be creative, and to live together and with nature in peace and harmony. When nations ensure that such an education is accessible to all throughout their lives, a quiet revolution is set in motion: education becomes the engine of sustainable development and the key to a better world.'

Higher education in sustainability across education streams including engineering, finance, supply chain and operations is gaining weight-age. Multiple institutes including Wharton, Columbia, CASI Global New York offer certifications in Sustainability. Corporate's prefer employees certified in sustainability.

Reference <https://www.wharton.upenn.edu/> <http://www.columbia.edu/> <http://casiglobal.us/>

Insubstantial stretching of the term

It has been argued that since the 1960s, the concept of sustainable development has changed from "conservation management" to "economic development", whereby the original meaning of the concept has been stretched somewhat.

In the 1960s, the international community realised that many African countries needed national plans to safeguard wildlife habitats, and that rural areas had to confront the limits imposed by soil, climate and water availability. This was a strategy of conservation management. In the 1970s, however, the focus shifted to the broader issues of the provisioning of basic human needs, community participation as well as appropriate technology use throughout the developing countries (and not just in Africa). This was a strategy of economic development, and the strategy was carried even further by the Brundtland Commission's report on *Our Common Future* when the issues went from regional to international in scope and application. In effect, the conservationists were crowded out and superseded by the developers.

But shifting the focus of sustainable development from conservation to development has had the imperceptible effect of stretching the original forest management term of sustainable yield from the use of renewable resources only (like forestry), to now also accounting for the use of non-renewable resources (like minerals). This stretching of the term has been questioned. Thus, environmental economist Kerry Turner has argued that literally, there can be no such thing as overall "sustainable development" in an industrialised world economy that remains heavily dependent on the extraction of earth's finite stock of exhaustible mineral resources: "It makes no sense to talk about the sustainable use of a non-renewable resource (even with substantial recycling effort and use rates). Any positive rate of exploitation will eventually lead to exhaustion of the finite stock."

In effect, it has been argued that the industrial revolution as a whole is unsustainable.

One critic has argued that the Brundtland Commission promoted nothing but a business as usual strategy for world development, with the ambiguous and insubstantial concept of "sustainable development" attached as a public relations slogan: The report on *Our Common Future* was largely the result of a political bargaining process involving many special interest groups, all put together to create a common appeal of political acceptability across borders. After World War II, the notion of "development" had been established in the West to imply the projection of the American model of society onto the rest of the world. In the 1970s and 1980s, this notion was broadened somewhat to also imply human rights, basic human needs and finally, ecological issues. The emphasis of the report was on helping poor nations out of poverty and meeting the basic needs of their growing populations—as usual. This issue demanded more economic growth, also in the rich countries, who would then import more goods from the poor countries to help them out—as usual. When the discussion switched to global ecological limits to growth, the obvious dilemma was left aside by calling for economic growth with improved resource efficiency, or what was termed "a change in the *quality* of growth". However, most countries in the West had experienced such improved resource efficiency since the early-20th century already and as usual; only, this improvement had been more

than offset by continuing industrial expansion, to the effect that world resource consumption was now higher than ever before—and these two historical trends were completely ignored in the report. Taken together, the policy of perpetual economic growth for the entire planet remained virtually intact. Since the publication of the report, the ambiguous and insubstantial slogan of "sustainable development" has marched on worldwide (Sustainable development).

1.7 SELF-ASSESSMENT TEST

- Elucidate the ecological systems of the Earth and how they interact?
- Differentiate between endogenetic and exogenetic forces. How these two forces interact to give rise to the present configuration of the earth?
- Define sustainable development. What are the aims and objectives of sustainable development?
- Define Human Development Index? What are the basic parameters of Human Development Index?

1.8 SUMMARIES AND KEY POINTS

The present section introduces the ecological system of the earth- atmosphere, lithosphere, hydrosphere and biosphere. It discusses the endogenetic forces- interior of the earth and surface configuration; exogenetic forces and resultant landforms- fluvial and arid landforms.

It introduces the concept of land and land use; land capability classification, carrying capacity of land. It discusses the measuring land surface-concept of scale and map, procedures of land survey and map making using tape and theodolite. Concept of society and space, material and social space, social structure, social processes, cultural realms and cultural diffusion are also discussed. Rural and urban settlements and its classification, Human Development Index, Sustainable development have been discussed.

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UNIT-9

CONCEPT AND CLASSIFICATION OF RESOURCES, CONVENTIONAL AND NON-CONVENTIONAL RESOURCES

Etymologically, 'resource' consists of two separate words—'re' and 'source'—that refers to anything or substance that may occur unhindered many more times. The term 'Resource' had no special significance till the early part of the twentieth century. Only in 1933, when the eminent professor of economics Erich W. Zimmermann promulgated his famous "Concept of Resource", the idea became so popular that numerous articles and papers started pouring in the contemporary Economic Geographical literature. Urgent need was felt to identify the new concept as a separate and important branch of study.

The term "resource" denote:

- (a) a source or possibility of assistance.
- (b) an expedient:
- (c) means of support.
- (d) means to attain given end.
- (e) capacity to take advantage of opportunities.
- (f) that upon which one relies for aid, support or supply.

The above definitions vary markedly and fail miserably to produce any comprehensive universally accepted meaning of resource. However, after critical examinations and analyses all these meanings can be grouped into two, i.e., resources may help us if we are:

- (a) taking advantage of opportunity.
- (b) overcoming obstacles or resistances.

The first is a positive approach, the second role of resource is, surely, negative.

Resource can be subjective as well as objective. Subjective resource denotes internal resource, objective resource is external resource.

Prof. Zimmermann defines resource as: "The word resource does not refer to a thing or a substance but to a function which a thing or a substance may perform or to an operation in which it may take part, namely, the function or operation of attaining a given end such as satisfying a want. In other words, the word resource is an abstraction reflecting human appraisal and relating to a function or operation".

So, resource satisfies individual human wants or attains social objectives. It also refers to the positive interaction between man and nature. Man is, of course, the most important and integral part of resource creation, as he is situated in the top of the hierarchy of resource consumption, Only the satisfaction of human beings converts anything or a substance into resource.

A thing or substance is not considered as resource when it fails to give satisfaction to human beings. Proven reserves of petroleum or coal in inaccessible terrain, is not considered resource as they fail to yield any satisfaction to either society or individual. Geo-thermal energy in this contemporary world is considered to be the most useful resource, but, till recently, this was not considered as resource, because man was not capable to harness this resource.

Resource must possess two important properties:

a) Functionability

b) Utility.

To define anything or substance as resource, one must critically examine whether it has the property of both utility and functionability. The presence of both utility and functionability is mandatory for resource creation, For example, a bottle of poison has functionability but it has got no utility value as food. The functionability is also the function of space and time. The resource of yesteryears may not be considered as resource today, resource considered by one country may be considered as waste product by another country, e.g., frog is considered as delicious food in Europe while it is not edible in large sections of India. Petroleum was not considered as resource until 27th August 1859, since the world's first commercial oil-well was dug at Titusville, Pennsylvania, US.A. (Roy, 2005).

The concept of resources has been applied in diverse realms, with respect to economics, biology and ecology, computer science, management, and human resources, and is linked to the concepts of competition, sustainability, conservation, and stewardship. In application within human society, commercial or non-commercial factors require resource allocation through resource management. Resources have three main characteristics: utility, limited availability, and potential for depletion or consumption. Resources have been variously categorized as biotic versus abiotic, renewable versus non-renewable, and potential versus actual, with more elaborate classification.

In economics a resource is defined as a service or other asset used to produce goods and services that meet human needs and wants. Economics itself has been defined as the study of how society manages its scarce resources. Classical economics recognizes three categories of resources, also referred to as factors of production: land, labour, and capital. Land includes all natural resources and is viewed as both the site of production and the source of raw materials. Labour or human resources consist of human effort provided in the creation of products, paid in wage. Capital consists of human-made goods or means of production used in the production of other goods and services, paid in interest.

In biology and ecology a resource is defined as a substance that is required by a living organism for normal growth, maintenance, and reproduction. The main essential resources for animals are food, water, and territory. For plants key resources include sunlight, nutrients, water, and a place to grow. Resources, can be consumed by an organism and, as a result, become unavailable to other organisms. Competition for resources vary from complete symmetric (all individuals receive the same amount of resources, irrespective of their size) to perfectly size symmetric (all individuals exploit the same amount of resource per unit biomass) to absolutely size-asymmetric (the largest individuals exploit all the available resource). The degree of size asymmetry has major effects on the structure and diversity of ecological communities, e.g. in plant communities size-asymmetric competition for light has stronger effects on diversity compared with competition for soil resources. The degree of size asymmetry has major effects on the structure and diversity of ecological communities.

There are three fundamental differences between economic versus ecological views: 1) the economic resource definition is human-centered (anthropocentric) and the biological or ecological resource definition is nature-centered (biocentric or ecocentric); 2) the economic view includes desire along with necessity, whereas the biological view is about basic biological needs; and 3) economic systems are based on markets of currency exchanged for goods and services, whereas biological systems are based on natural processes of growth, maintenance, and reproduction.

A computer resource is any physical or virtual component of limited availability within a computer or information management system. Computer resources include means for input, processing, output, communication, and storage.

Natural resources are derived from the environment. Many natural resources are essential for human survival, while others are used for satisfying human desire. Conservation is the management of natural resources with the goal of sustainability. Natural resources may be further classified in different ways (Resource).

RESOURCE AND WEALTH

In day-to-day life, a common man often uses the terms resource and wealth for same purpose and meaning. Both the words signify the same expression. But, in economics and resource study, these words convey separate meanings. Wealth, as stated by noted economist J. M. Keynes, “consists of all potentially exchangeable means of satisfying human wants”. So, wealth must possess Utility, Functionability, Scarcity and Transferability. Wealth is always measurable, i.e., wealth can be expressed in terms of measuring units, like rupees and dollars etc. In this way, culture cannot be considered a wealth because it cannot be expressed by any measuring unit.

On the contrary, resource may be tangible as well as intangible substances. Anything satisfying human wants can be termed as resource be it tangible or not. Wealth is synonymous with valuables, i.e., it should be scarce while resource may be ubiquitous or abundant, e.g., soil, sunshine, air etc.

Hence, it may be concluded that, all wealth are resource but all resources are not wealth, Resource incorporates much broader meaning than wealth in a sense that culture, technology, innovative power, skill and different other aspects are included in the realm of resource (Roy, 2005).

SOME MISCONCEPTIONS ABOUT RESOURCES

Since time immemorial, consciousness about resource is a part of both individual and society, In fact, when human beings began community life to attain security and richness individuals started to gather wealth and power for future resource creation. For the three basic necessities of survival —food, shelter and clothing —man had no other option but to be aware about the resources.

Even since Industrial Revolution (1760), the values, ethics, culture, community life, agrarian economy all underwent radical changes. New concepts of social welfare state, ultra-capitalism, economic colonialism affected human life. To combat this, emergence of socialism, communism again increased the differences between different schools of thought.

According to the prevailing changes in society in different era, the concept of resources had also gone through changes—in harmony with space and time.

The major popular misconceptions about resource in earlier periods were:

1. Substances or tangible things like coal, copper, petroleum etc. are resources.
2. Invisible or intangible aspects—peace, culture, wisdom, policy, decisions, knowhow, knowledge, freedom —cannot be considered as resource.

3. Only natural things or substances, freely bestowed by mother earth, can be considered resource. Resource cannot be created.
4. Human populations were not considered as resource.
5. Only the quantum and magnitude of substances, not their usability or functionability and quality, were measured.
6. Resource was considered as mere 'static' and fixed asset, its mobility, dynamism and expansionability was totally ignored.
7. The concept of resistance was totally unknown. So, matter full of resistance and no functionability was also considered as resource.

In pre-Zimmermann era, only tangible or material substances were considered resources. Different minerals like iron ore, copper, bauxite, different fuels like coal, petroleum etc. were considered resource while intangible things like peace, culture, wisdom, policy decisions etc. were not considered as resource. Zimmermann felt the inadequacy of the prevailing concept of resource and wrote "...Whereas less important invisible and intangible aspects — such as health, social harmony, wise policies, knowledge, freedom — are ignored, even though possibly these latter are more important than all the coal, iron, gold and silver in the world put together, In fact, resources evolve out of the dynamic interaction of all these factors".

In those days, widespread belief was 'Resource cannot be created'. It is a free gift of nature. Only the natural things or substances can be considered as resource. Creation, modification or extension of resource was practically unknown to that medieval world.

The role of man was grossly underestimated in earlier times. Only after the resource concept was introduced role of man in the overall resource creation process was understood. In this context we can recall the legendary remarks of Prof. Zimmerman: "man's wisdom is his premier resource—the key resource that unlocks the universe."

Considering resource as a static or fixed asset was another misconception In those days. In reality, the potential ability of resource cannot be measured precisely, as, always, it may increase with improved technologic al advancement, Zimmerman opined that resource is as dynamic as the civilization itself.

Early geographers were totally ignorant about the property of resistance hidden within things or substances. If resourcefulness is considered as positive aspect of resource, resistance is the opposite to that of resource like assets and liabilities or profit and loss (Roy, 2005).

RESOURCE, RESISTANCE AND NEUTRAL STUFF

There is a opposite relationship between resource and resistance. This inverse relationship is the key issue in the overall scheme of resource creation. Anything or any process that hinders a substance from becoming resource is called resistance. Fertility of soil is resource but barrenness is resistance. Rain may be considered resource but flood is resistance. Prof. Zimmermann defines neutral stuff as anything or substance does not contain functionability or utility value, it is termed neutral stuff. Anything or substance, be it tangible or intangible, should be either resource or neutral stuff. Neutras stuff should not necessarily remain neutral forever. What is considered neutral stuff today may transform into resource tomorrow. Man's knowledge, wisdom and technological innovation may

transform neutral stuff into precious resource, e.g., petroleum was not considered resource until 1659, because man was quite ignorant about its uses while, with the development of science and technology, it is now considered as a mainstay for harnessing energy.

The process of economic development is directly proportional with the rate of conversion of neutral stuff into resource. The advancement of modern civilization is synonymous with the transformation of neutral stuff into resource (Roy, 2005).

FUNCTIONAL THEORY OF RESOURCES

“Resources were defined as means of attaining given ends, i.e., individual wants and social objectives, Means take their meaning from the ends which they serve. As ends change means must change also” This statement of Zimmermann clearly states that resource creation is a function of space and time. With increasing knowledge, function of resource may enhance: A primitive man may not be able to harness resource from a substance but a modern man is capable of transforming such simple substance resource. For a modern Man, knowledge plays a key role to convert neutral stuff into resource.

The tropical Africa is well endowed with huge water resources. Due to backward economy and technological drawbacks, inhabitants of that region cannot convert it into energy. On the contrary, the Japanese were able to produce huge energy from far less water resources. This is because of scientific knowledge, expertise and greater economic development. The advancement of civilization is the product of expansion of human information base. Information about minerals —coal, petroleum, iron ore, copper etc, about agriculture—HYV seeds, pesticides, insecticides etc., about manufacturing industry — the invention of steam engines, boilers, turbines, converters etc., were possible with the increasing scientific knowledge. This increasing knowledge reduced the resistances of the natural things or substances and converted them to resources. So, Wesley C. Mitchel had aptly said: "Incomparably greatest among human resources is knowledge".

So, with the efforts of man, through the functional or operational process, resource is dynamically created. Without human effort resource cannot be created because man is the ultimate consumer of resource. Without any operational process, a thing or substance remains neutral, resource cannot be created and what is created now may be enhanced or increased with increasing knowledge. So, resource creation process is highly dynamic in nature (Roy, 2005).

DYNAMIC CONCEPT OF RESOURCE

Prof. Hamilton said: “It is technology which gives value to the neutral stuffs which it processes; and as the useful arts advance the gifts of nature are remade. With technology on the march, the emphasis of value shifts from the natural to the processed good”. So, resource creation process is not static, it is dynamic in nature. The thing or substance considered _as neutral stuff today may be converted into precious resource tomorrow. Since the beginning of civilization, paleolithic man started devoting his limited knowledge to convert neutral stuff into resource for his own requirement. With the passage of time, with increasing knowledge, man was able to harness more resource from same amount of stuff. Bowman has rightly remarked: “The moment we give them human association they are as changeable as humanity itself”

With the increasing need, man frantically explored all possibilities or avenues to expand resource base from his existing stock. So, resource creation is a continuous and need-based operation. At the present era, when the world is passing through acute energy crisis, man is exploring possibilities to produce energy from all sources—solar energy, wind energy, geothermal energy etc. Previously ocean current was never considered as resource but, now, man is able to convert this force into energy. So, the concept of resource is dynamic and resource study is a dynamic science (Roy, 2005).

RESOURCE-CREATING FACTORS

Three most important resource-creating factors are nature, culture and man. Their dynamic interaction ultimately culminates into creation of resource.

Nature

Nature sets the limits within which man can develop his art to satisfy his wants - According to this concept of Zimmermann, nature is the storehouse of all natural or tangible resources, The gifts of nature, however, are rarely used by mankind in its unaltered But almost all types of tangible things are direct or indirect product of nature. The functions of natural resources are related with the capabilities of mankind. The endowment of nature, e.g., soil, water bodies, climate — together, as also the ability of mankind are the pivotal forces of resource creation,

Culture

If man and nature are the causes, culture or the end-product is the effect. Culture is, thus called the joint product of man and nature. Nature and man are the two most important inputs, the output will be culture. All human activities are, directly or indirectly, influenced by cultural practice, which varies distinctly from place to place. Culture is not static and neither is it confined to a particular place. The economic development of a region is greatly influenced by its culture. Mobility of economy depends on the dynamism of culture.

Man

Among the three resource-creating factors— nature, culture and man, undoubtedly man is the key factor or pivotal force for resource creation. The interaction of this dynamic entity man with his surrounding yields resource. Man —with his rationality, wisdom and need, converts neutral stuff into resource. It contains two aspects: qualitative and quantitative. Of course qualitative aspect is most important. The qualitative superior manpower may harness more resource, even if the quantity is low. On the other hand, if quantity of manpower is high but quality is low, the end-product will be inferior and resource will be underutilised. This has been the case of Antarctica, and, to some extent, in sub-polar region of northern hemisphere and equatorial rainforest region of the globe (Roy, 2005).

Classification of Resources

Resources can be classified on the basis of origin:

- Abiotic resources comprise non-living things (e.g., land, water, air and minerals such as gold, iron, copper, silver).
- Biotic resources are obtained from the biosphere. Forests and their products, animals, birds and their products, fish and other marine organisms are important examples. Minerals such as coal and petroleum are sometimes included in this category because they were formed from fossilized organic matter, though over long periods of time.

Natural resources are also categorized based on the stage of development:

- Potential resources are known to exist and may be used in the future. For example, petroleum may exist in many parts of India and Kuwait that have sedimentary rocks, but until the time it is actually drilled out and put into use, it remains a potential resource.
- Actual resources are those that have been surveyed, their quantity and quality determined, and are being used in present times. For example, petroleum and natural gas is actively being obtained from the Mumbai High Fields. The development of an actual resource, such as wood processing depends upon the technology available and the cost involved. That part of the actual resource that can be developed profitably with available technology is called a reserve resource, while that part that cannot be developed profitably because of lack of technology is called a stock resource.

Natural resources can be categorized on the basis of renewability:

- Non-renewable resources are formed over very long geological periods. Minerals and fossils are included in this category. Since their rate of formation is extremely slow, they cannot be replenished, once they are depleted. Out of these, the metallic minerals can be re-used by recycling them, but coal and petroleum cannot be recycled.
- Renewable resources, such as forests and fisheries, can be replenished or reproduced relatively quickly. The highest rate at which a resource can be used sustainably is the sustainable yield. Some resources, like sunlight, air, and wind, are called perpetual resources because they are available continuously, though at a limited rate. Their quantity is not affected by human consumption. Many renewable resources can be depleted by human use, but may also be replenished, thus maintaining a flow. Some of these, like agricultural crops, take a short time for renewal; others, like water, take a comparatively longer time, while still others, like forests, take even longer.

Dependent upon the speed and quantity of consumption, overconsumption can lead to depletion or total and everlasting destruction of a resource. Important examples are agricultural areas, fish and other animals, forests, healthy water and soil, cultivated and natural landscapes. Such conditionally renewable resources are sometimes classified as a third kind of resource, or as a subtype of renewable resources. Conditionally renewable resources are presently subject to excess human consumption and the only sustainable long term use of such resources is within the so-called zero ecological footprint, wherein human use less than the Earth's ecological capacity to regenerate.

Natural resources are also categorized based on distribution:

- Ubiquitous resources are found everywhere (e.g., air, light, water).
- Localized resources are found only in certain parts of the world (e.g., copper and iron ore, geothermal power).

Actual vs. potential natural resources are distinguished as follows:

- Actual resources are those resources whose location and quantity are known and we have the technology to exploit and use them.
- Potential resources are the ones of which we have insufficient knowledge or we do not have the technology to exploit them at present.

On the basis of ownership, resources can be classified as individual, community, national, and international.

In economics, labour or human resources refers to the human effort in production of goods and rendering of services. Human resources can be defined in terms of skills, energy, talent, abilities, or knowledge. In a project management context, human resources are those employees responsible for undertaking the activities defined in the project plan.

In social studies, capital refers to already-produced durable goods used in production of goods or services. In essence, capital refers to human-made resources created using knowledge and expertise based on utility or perceived value. Common examples of capital include buildings, machinery, railways, roads, and ships. As resources, capital goods may or may not be significantly consumed, though they may depreciate in the production process and they are typically of limited capacity or unavailable for use by others.

Whereas, tangible resources such as equipment have actual physical existence, intangible resources such as corporate images, brands and patents, and other intellectual property exist in abstraction. Generally the economic value of a resource is controlled by supply and demand (Resource).

Conventional and Non-Conventional Resources

Natural resources can be categorized on the basis of renewability:

- Conventional resources are non-renewable resources. They are formed over very long geological periods. Minerals and fossils are included in this category. Since their rate of formation is extremely slow, they cannot be replenished, once they are depleted. Out of these, the metallic minerals can be re-used by recycling them, but coal and petroleum cannot be recycled.
- Non conventional resources are renewable resources, such as forests and fisheries, can be replenished or reproduced relatively quickly. The highest rate at which a resource can be used sustainably is the sustainable yield. Some resources, like sunlight, air, and wind, are called perpetual resources because they are available continuously, though at a limited rate. Their quantity is not affected by human consumption. Many renewable resources can be depleted by human use, but may also be replenished, thus maintaining a flow. Some of these, like agricultural crops, take a short time for renewal; others, like water, take a comparatively longer time, while still others, like forests, take even longer.

UNIT-10

DISTRIBUTION OF ENERGY RESOURCES- COAL

Coal is a combustible black or brownish-black sedimentary rock, formed as rock strata called **coal seams**. Coal is mostly carbon with variable amounts of other elements; chiefly hydrogen, sulfur, oxygen, and nitrogen. Coal is formed if dead plant matter decays into peat and over millions of years the heat and pressure of deep burial converts the peat into coal. Vast deposits of coal originates in former wetlands—called coal forests—that covered much of the Earth's tropical land areas during the late Carboniferous (Pennsylvanian) and Permian times.

As a fossil fuel burned for heat, coal supplies about a quarter of the world's primary energy and two-fifths of its electricity. Some iron and steel making and other industrial processes burn coal.

The extraction and use of coal causes many premature deaths and much illness. Coal damages the environment, including by climate change as it is the largest anthropogenic source of carbon dioxide, 14 Gt in 2016, which is 40% of the total fossil fuel emissions. As part of the worldwide energy transition many countries have stopped using or use less coal, and the UN Secretary General has asked governments to stop building new coal plants by 2020.

The largest consumer and importer of coal is China. China mines almost half the world's coal, followed by India with about a tenth. Australia accounts for about a third of world coal exports followed by Indonesia and Russia.

Geology

Coal is composed of macerals, minerals and water. Fossils and amber may be found in coal.

Formation

At various times in the geologic past, the Earth had dense forests in low-lying wetland areas. Due to natural processes such as flooding, these forests were buried underneath soil. As more and more soil deposited over them, they were compressed. The temperature also rose as they sank deeper and deeper. As the process continued the plant matter was protected from biodegradation and oxidation, usually by mud or acidic water. This trapped the carbon in immense peat bogs that were eventually covered and deeply buried by sediments. Under high pressure and high temperature, dead vegetation was slowly converted to coal. The conversion of dead vegetation into coal is called coalification. Coalification starts with dead plant matter decaying into peat. Then over millions of years the heat and pressure of deep burial causes the loss of water, methane and carbon dioxide and an increase in the proportion of carbon. Thus first lignite (also called "brown coal"), then sub-bituminous coal, bituminous coal, and lastly anthracite (also called "hard coal" or "black coal") may be formed.

The wide, shallow seas of the Carboniferous Period provided ideal conditions for coal formation, although coal is known from most geological periods. The exception is the coal gap in the Permian–Triassic extinction event, where coal is rare. Coal is known from Precambrian strata, which predate land plants—this coal is presumed to have originated from residues of algae.

Sometimes coal seams (also known as coal beds) are interbedded with other sediments in a cyclothem.

Types

As geological processes apply pressure to dead biotic material over time, under suitable conditions, its metamorphic grade or rank increases successively into:

- Peat, a precursor of coal
- Lignite, or brown coal, the lowest rank of coal, most harmful to health, used almost exclusively as fuel for electric power generation
- Jet, a compact form of lignite, sometimes polished; used as an ornamental stone since the Upper Palaeolithic
- Sub-bituminous coal, whose properties range between those of lignite and those of bituminous coal, is used primarily as fuel for steam-electric power generation.
- Bituminous coal, a dense sedimentary rock, usually black, but sometimes dark brown, often with well-defined bands of bright and dull material. It is used primarily as fuel in steam-electric power generation and to make coke.
- Anthracite, the highest rank of coal is a harder, glossy black coal used primarily for residential and commercial space heating.
- Graphite is difficult to ignite and not commonly used as fuel; it is most used in pencils, or powdered for lubrication.

Cannel coal (sometimes called "candle coal") is a variety of fine-grained, high-rank coal with significant hydrogen content, which consists primarily of liptinite.

There are several international standards for coal. The classification of coal is generally based on the content of volatiles. However the most important distinction is between thermal coal (also known as steam coal), which is burnt to generate electricity via steam; and metallurgical coal (also known as coking coal), which is burnt at high temperature to make steel.

Hilt's law

Hilt's law is a geological observation that (within a small area) the deeper the coal is found, the higher its rank (or grade). It applies if the thermal gradient is entirely vertical; however, metamorphism may cause lateral changes of rank, irrespective of depth (Coal).

Coal mining regions

Coal mining regions are significant resource extraction industries in many parts of the world. They provide a large amount of the fossil fuel energy in the world economy.

The People's Republic of China is the largest producer of coal in the world, while the United States contains the world's largest 'recoverable' coal reserves (followed by Pakistan, Russia, China, and India). China and the United States are also among the largest coal consumers. Other important coal producing countries include Australia, India, South Africa, and Russia.

A **coal-mining region** is a region in which coal mining is a significant economic activity. Coal-mining regions are often associated with the social, environmental and cultural impact of coal mining.

United States

Coal mining in the United States has historically had economic and cultural dominance in regions such as the Allegheny Mountains and Appalachian Mountains, where it was a major part of identity and traditions. The replacement of workers by mechanization has had major consequences for the industry and for the people it affects.

Coal is mined in the Appalachian Mountains region, and the Midwest. Most coal now produced in the United States is mined in western surface mines, especially in Wyoming's Powder River Basin. A surface mining method often used in the Appalachians is mountaintop removal mining.

The states with the largest recoverable coal reserves are, in descending order, Wyoming, West Virginia, Illinois, and Montana. The largest single mine in the United States is the North Antelope Rochelle near Gillette, Wyoming; it produces more coal annually than many states. In 2009, it alone produced over 100 million tons of coal, and has plans to produce 130 million ton in 2012 more than 23 other coal producing states including Pennsylvania.

Areas with significant coal mining activities include:

- Coal Region of Pennsylvania - One of the largest deposits of anthracite coal, the region is in Northeastern Pennsylvania, in the central Appalachian Mountains comprising Lackawanna, Luzerne, Columbia, Carbon, Schuylkill, Northumberland, and the extreme northeast corner of Dauphin counties. Major population centers include Scranton, Wilkes-Barre, and Pottsville.
- West Virginia - see economy of West Virginia
- Eastern Mountain Coal Fields and Western Coal Fields of Kentucky
- Southern Illinois Coal Fields, including the Harrisburg Coal Field
- Colorado - including Denver Basin.
- Powder River Basin
- Raton Basin

Europe

Silesia in Poland and Czech Republic has more working coal miners than the rest of the European Union combined.

United Kingdom - Britain had major coal-mining activity in the past, but since the 1980s coal mining has been in decline due to the increased use of natural gas in power stations and cheaper imports. Very few working coal mines and open-cast quarries now exist in Britain.

In **England**, the West Midlands region, which covers the western part of the English Midlands. The West Midlands conurbation is the name given to the large conurbation in the region that includes the cities of Birmingham and Wolverhampton. The "**Black Country**" is a loosely defined area of the English West Midlands which includes the north and west of Birmingham and the south and east of Wolverhampton, famous for its coal mines (especially in Staffordshire), its coal coking operations, and other heavy industry, including iron foundries and steel mills that used local coal to fire their furnaces, all of which produced a level of air pollution that had few equals anywhere in the world.

The Kent coalfield in Kent in South East England also had coal mining operations. In South West England, Somerset was the location of the Somerset coalfields until 1973. Yorkshire in North West England also was formerly home to major coal mining operations. In **Wales**, the South Wales coalfield provided a large amount of Welsh coal.

Spain

There are large coal deposits in Asturias and León which helped fuel the Industrial Revolution in Spain; these have mostly been exhausted.

Ukraine

Donbas, Volyn, and Halychyna are coal-mining regions.

Romania

The Jiu Valley is a coal-mining region.

Serbia

Kolubara and Kostolac are coal mining regions. The REMBAS region near the Resava River is a coal-mining region.

Germany

The Ruhr Area in North Rhine-Westphalia, Lower Lusatia, and the Central Germany lignite mining area are some of the coal-mining regions. End of 2010 there were five operating hard coal mines in Germany: 1: Bergwerk Ibbenbüren, Ibbenbüren, 2: Zeche Auguste Viktoria, Marl, 3: Bergwerk Prosper-Haniel, Bottrop, 4: Bergwerk West, Kamp Lintfort, 5: Bergwerk Saar, Saarlouis.

Germany's last operating black coal mine, Prosper-Haniel, closed on Dec. 21, 2018.

Netherlands

Limburg was a coal-mining region until 1973; See mining in Limburg

France

Nord-Pas de Calais Mining Basin, Loire coal mining basin and Saar-Warndt coal mining basin were the major coal-mining regions.

Belgium

The sillon industriel contains the former coal-mining area, Pays Noir, or "Black Country." It runs across Wallonia, passing from Dour, in Borinage, in the west, to Verviers in the east, through Mons, La Louvière, Charleroi, Namur, Huy, and Liège, following the valleys of the rivers Haine, Sambre, Meuse and Vesdre. It is also known as the "Sambre and Meuse valley", or the "Haine-Sambre-Meuse-Vesdre valley", or the "dorsale wallonne."

Russia

Kuznetsk Basin of southwestern Siberia is a coal-mining region.

Australia

Australia contains 76 billion tonnes of coal reserves, or approximately 8 percent of known worldwide deposits. Australian coal deposits include both lignite (brown coal) and black coal. The premier producing areas for Australian coal are the Bowen Basin in the state of Queensland, the Hunter Region in the state of New South Wales, and the Latrobe Valley in the state of Victoria.

China

China is currently the world's largest coal miner, and it is also the largest consumer of coal in the world. China's coal output has continued to increase and its production capacity has expanded at an unprecedented rate, with an annual increase in production of 200 million tonnes on average. In 2012, the total output of coal reached 3.66 billion tonnes. However, based on China's existing coal mining technologies, this level of output greatly exceeds the sustainable coal production capacity in terms of resources, the environment, and safety. Behind this huge production statistic are excessive waste of coal resources, a large number of casualties among workers, and serious damage to water resources and the environment. These problems are the basis of resistance for the continued development of China's coal industry.

Mongolia

Mongolia has proven reserves of 12.2 billion tons of coal including 2 billion tons of coking coal and 10.1 billion tons of thermal coal. Mongolia is estimated to have potential coal reserves of some 100 billion metric tonnes. While Mongolia's output is approximately only 5 million tonnes of coal per year, it will grow significantly given its proximity to China.

India

India has some of the largest reserves of coal in the world (approx. 267 billion tonnes). The energy derived from coal in India is about twice that of energy derived from oil, whereas worldwide, energy derived from coal is about 30% less than energy derived from oil.

The top producing states are:

- Chhattisgarh
- Orissa
- Jharkhand

Other notable coal-mining areas include:

- Singareni collieries in Khammam district, Telangana
- Chirimiri Coalfield And Hasdeo coalfield in Koriya District, Chhattisgarh
- Jharia mines in Dhanbad district, Jharkhand
- Orissa
- Nagpur & Chandrapur district, Maharashtra
- Raniganj in Bardhaman district, West Bengal
- Neyveli lignite mines in Cuddalore district, Tamil Nadu

- Singrauli Coalfield and Umaria Coalfield in Madhya Pradesh
- Jowai, Garo hills in Meghalaya

Pakistan

The discovery of a vast deposit in Sindh Province in the 1990s, has led to a JORC resource, in the region of 175 Billion tonnes, work is ongoing with production expected to commence in 2013, with several foreign companies competing to mine various blocks of the resource.

South Africa

In South Africa coal is mined in several regions, mainly in the East Rand around Witbank, in the Vaal valley around the Vaal Triangle, the Waterberg in the Limpopo Province and at Dundee and Newcastle in northern KwaZulu Natal. South Africa is currently the leading African coal producer.

Russia

Russia is currently the fifth largest producer of coal, and has the second largest reserves, estimated at 175 billion. The majority of its coal is located behind the Ural Mountains in Siberia. By 1999 approximately a third of coal mining business was privatized. Since then, the industry has concentrated in hands of few companies - coking coal producers were integrated with steel makers, and two national leaders in steam coal emerged. Russian coal miners have recently campaigned for improvements in their working conditions, leading to some reform. Mechel controls the Southern Kuzbass Coal Company in Kuznetsk, the Elga Coal Field in the Sakha Republic with 2.2 billion metric tons of reserves of coal, and the Neryungri coal mine at Neryungri in the Sakha Republic. Other coal producing regions include the Pechora basin of brown coal in northern European Russia, the Kansk-Achinsk basin with total reserves 600 billion tons of lignite centered on Kansk in southern Krasnoyarsk Krai, Tunguska coal basin in eastern Siberia located between the Khatanga River to the Trans-Siberian railway and between the Yenisei and Lena rivers, and the Lena coal basin which is mainly in the Sakha Republic with some in Krasnoyarsk Krai.

Canada

Canada holds 78 billion tonnes of coal, primarily bituminous and sub-bituminous, though Saskatchewan holds significant reserves of lignite coal. The Elk Valley, located in the southeast corner of British Columbia, is host to one of the world's largest deposits of hard coking coal. Five mines are operated by the Teck mining company in this area (Coal Mining Region).

Damages to human health

The use of coal as fuel causes ill health and deaths.

The deadly London smog was caused primarily by the heavy use of coal. Globally coal is estimated to cause 800,000 premature deaths every year, mostly in India and China.

Breathing in coal dust causes coal worker's pneumoconiosis which is known colloquially as "black lung", so-called because the coal dust literally turns the lungs black from their usual pink color. In the United States alone, it is estimated that 1,500 former employees of the coal industry die every year from the effects of breathing in coal mine dust.

Around 10% of coal is ash: coal ash is hazardous and toxic to human beings and some other living things. Coal ash contains the radioactive elements uranium and thorium. Coal ash and other solid combustion by products are stored locally and escape in various ways that expose those living near coal plants to radiation and environmental toxics.

Huge amounts of coal ash and other waste is produced annually. Use of coal generates hundreds of millions of tons of ash and other waste products every year. These include fly ash, bottom ash, and flue-gas desulfurization sludge, that contain mercury, uranium, thorium, arsenic, and other heavy metals, along with non-metals such as selenium.

Coal smokestack emissions cause asthma, strokes, reduced intelligence, artery blockages, heart attacks, congestive heart failure, cardiac arrhythmias, mercury poisoning, arterial occlusion, and lung cancer.

Annual health costs in Europe from use of coal to generate electricity are estimated at up to €43 billion.

In China, improvements to air quality and human health would increase with more stringent climate policies, mainly because the country's energy is so heavily reliant on coal. And there would be a net economic benefit.

A 2017 study in the *Economic Journal* found that for Britain during the period 1851–1860, "a one standard deviation increase in coal use raised infant mortality by 6–8% and that industrial coal use explains roughly one-third of the urban mortality penalty observed during this period."

Damages to the environment

Coal mining and coal fueling of power stations and industrial processes can cause major environmental damage.

Water systems are affected by coal mining. For example, mining affects groundwater and water table levels and acidity. Spills of fly ash, such as the Kingston Fossil Plant coal fly ash slurry spill, can also contaminate land and waterways, and destroy homes. Power stations that burn coal also consume large quantities of water. This can affect the flows of rivers, and has consequential impacts on other land uses. In areas of water scarcity, such as the Thar Desert in Pakistan, coal mining and coal power plants would use significant quantities of water.

One of the earliest known impacts of coal on the water cycle was acid rain. Approximately 75 Tg/S per year of sulfur dioxide (SO₂) is released from burning coal. After release, the sulfur dioxide is oxidized to gaseous H₂SO₂ which scatters solar radiation, hence its increase in the atmosphere exerts a cooling effect on climate. This beneficially masks some of the warming caused by increased greenhouse gases. However, the sulfur is precipitated out of the atmosphere as acid rain in a matter of weeks, whereas carbon dioxide remains in the atmosphere for hundreds of years. Release of SO₂ also contributes to the widespread acidification of ecosystems.

Disused coal mines can also cause issues. Subsidence can occur above tunnels, causing damage to infrastructure or cropland. Coal mining can also cause long lasting fires, and it has been estimated that thousands of coal seam fires are burning at any given time. For example, Brennender Berg has been burning since 1668 and is still burning in the 21st century.

The production of coke from coal produces ammonia, coal tar, and gaseous compounds as by-products which if discharged to land, air or waterways can pollute the environment. The Whyalla steelworks is one example of a coke producing facility where liquid ammonia is discharged to the marine environment.

Underground fires

Thousands of coal fires are burning around the world. Those burning underground can be difficult to locate and many cannot be extinguished. Fires can cause the ground above to subside, their combustion gases are dangerous to life, and breaking out to the surface can initiate surface wildfires. Coal seams can be set on fire by spontaneous combustion or contact with a mine fire or surface fire. Lightning strikes are an important source of ignition. The coal continues to burn slowly back into the seam until oxygen (air) can no longer reach the flame front. A grass fire in a coal area can set dozens of coal seams on fire. Coal fires in China burn an estimated 120 million tons of coal a year, emitting 360 million metric tons of CO₂, amounting to 2–3% of the annual worldwide production of CO₂ from fossil fuels. In Centralia, Pennsylvania (a borough located in the Coal Region of the United States), an exposed vein of anthracite ignited in 1962 due to a trash fire in the borough landfill, located in an abandoned anthracite strip mine pit. Attempts to extinguish the fire were unsuccessful, and it continues to burn underground to this day. The Australian Burning Mountain was originally believed to be a volcano, but the smoke and ash come from a coal fire that has been burning for some 6,000 years.

At Kuh i Malik in Yagnob Valley, Tajikistan, coal deposits have been burning for thousands of years, creating vast underground labyrinths full of unique minerals, some of them very beautiful.

The reddish siltstone rock that caps many ridges and buttes in the Powder River Basin in Wyoming and in western North Dakota is called *porcelanite*, which resembles the coal burning waste "clinker" or volcanic "scoria". Clinker is rock that has been fused by the natural burning of coal. In the Powder River Basin approximately 27 to 54 billion tons of coal burned within the past three million years. Wild coal fires in the area were reported by the Lewis and Clark Expedition as well as explorers and settlers in the area.

Global Warming

The largest and most long term effect of coal use is the release of carbon dioxide, a greenhouse gas that causes climate change and global warming. Coal is the largest contributor to the human-made increase of CO₂ in the atmosphere, 40% of the total. Coal mining can emit methane, another greenhouse gas.

In 2016 world gross carbon dioxide emissions from coal usage were 14.5 giga tonnes. For every megawatt-hour generated, coal-fired electric power generation emits around a tonne of carbon dioxide, which is double the approximately 500 kg of carbon dioxide released by a natural gas-fired electric plant. In 2013, the head of the UN climate agency advised that most of the world's coal reserves should be left in the ground to avoid catastrophic global warming.

Coal pollution mitigation

"Clean" coal technology usually addresses atmospheric problems resulting from burning coal. Historically, the primary focus was on SO₂ and NO_x, the most important gases which caused acid rain; and particulates which cause visible air pollution, illness and premature deaths. SO₂ can be removed by flue-gas desulfurization and NO₂ by selective catalytic reduction (SCR). Particulates can be removed with electrostatic precipitators. Although perhaps less efficient wet scrubbers can remove

both gases and particulates. And mercury emissions can be reduced up to 95%. However capturing carbon dioxide emissions is generally not economically viable.

Standards

Local pollution standards include GB13223-2011 (China), India, the Industrial Emissions Directive (EU) and the Clean Air Act (United States).

Satellite Monitoring

Satellite monitoring is now used to crosscheck national data, for example Sentinel-5 Precursor has shown that Chinese control of SO₂ has only been partially successful. It has also revealed that low use of technology such as SCR has resulted in high NO₂ emissions in South Africa and India.

Combined cycle power plants

A few Integrated gasification combined cycle (IGCC) coal-fired power plants have been built with coal gasification. Although they burn coal more efficiently and therefore emit less pollution, the technology has not generally proved economically viable for coal, except possibly in Japan although this is controversial.

Carbon capture and storage

Although still being intensively researched and considered economically viable for some uses other than with coal; carbon capture and storage has been tested at the Petra Nova and Boundary Dam coal-fired power plants and has been found to be technically feasible but not economically viable for use with coal, due to reductions in the cost of solar PV technology.

Economics

In the long term coal and oil could cost the world trillions of dollars. Coal alone may cost Australia billions, whereas costs to some smaller companies or cities could be on the scale of millions of dollars. The economies most damaged by coal (via climate change) may be India and the US as they are the countries with the highest social cost of carbon. Bank loans to finance coal are a risk to the Indian economy.

China is the largest producer of coal in the world. It is the world's largest energy consumer, and coal in China supplies 60% of its primary energy. However two fifths of China's coal power stations are estimated to be loss-making.

Air pollution from coal storage and handling costs the USA almost 200 dollars for every extra ton stored, due to PM_{2.5}. Coal pollution costs the EU €43 billion each year. Measures to cut air pollution benefit individuals financially and the economies of countries such as China.

Subsidies

Broadly defined total subsidies for coal in 2015 have been estimated at around US\$2.5 trillion, about 3% of global GDP. In the EU state aid to new coal-fired plants is expected to be banned from mid-2019 and to existing coal-fired plants from 2025. However government funding for new coal power plants is being supplied via Exim Bank of China, the Japan Bank for International Cooperation and Indian public sector banks. Coal in Kazakhstan was the main recipient of coal consumption subsidies totalling US\$2 billion in 2017. Coal in Turkey benefited from substantial subsidies.

Stranded assets

Some coal-fired power stations could become stranded assets, for example China Energy Investment, the world's largest power company, risks losing half its capital. However state owned electricity utilities such as Eskom in South Africa, Perusahaan Listrik Negara in Indonesia, Sarawak Energy in Malaysia, Taipower in Taiwan, EGAT in Thailand, Vietnam Electricity and EÜAŞ in Turkey are building or planning new plants.

Politics

Countries building or financing new coal-fired power stations, such as Japan, face mounting international criticism for obstructing the aims of the Paris Agreement. And Australia is being criticised by the Pacific Islands.

Corruption

Allegations of corruption are being investigated in India and China.

Opposition to coal

Opposition to coal pollution was one of the main reasons the modern environmental movement started in the 19th century.

Transition away from coal

In order to meet global climate goals and provide power to those that don't currently have it coal power must be reduced from nearly 10,000TWh to less than 2,000TWh by 2040. Many countries, such as the Powering Past Coal Alliance, have already or are transitioned away from coal; the largest transition announced so far being Germany which is due to shutdown its last coal-fired power station between 2035 and 2038. Some countries use the ideas of a "just transition", for example to use some of the benefits of transition to provide early pensions for coal miners. However low lying Pacific Islands are concerned the transition is not fast enough and that they will be inundated by sea level rise; so they have called for OECD countries to completely phase out coal by 2030 and other countries by 2040.

Peak coal

Although many countries have coal underground not all will be consumed.

Of the three fossil fuels, coal has the most widely distributed resources. Coal is mined on all continents except Antarctica. However many such resources have no economic value (much value has been destroyed by shale gas fracking). The largest resources are found in the United States, Russia, China, Australia and India:

Proved reserves at end 2017 (billion tonnes)				
Country	Anthracite & Bituminous	Sub Bituminous & Lignite	Total	Percentage of World Total
United States	221	30	251	24
Russia	70	90	160	16
Australia	68	77	145	14
China	131	8	139	13
India	93	5	98	9
World Total	718	317	1035	100

Nowadays "peak coal" means the point in time when consumption of coal reaches a maximum. As of 2018 global peak coal consumption is predicted to occur by the early 2020s at the latest.

Switch to cleaner fuels and lower carbon electricity generation

Coal-fired generation puts out about twice the amount of carbon dioxide—around a tonne for every megawatt hour generated—than electricity generated by burning natural gas at 500 kg of greenhouse gas per megawatt hour. In addition to generating electricity, natural gas is also popular in some countries for heating and as an automotive fuel.

The use of coal in the United Kingdom declined as a result of the development of North Sea oil and the subsequent dash for gas during the 1990s. In Canada some coal power plants, such as the Hearn Generating Station, switched from coal to natural gas. In 2017, coal power in the United States provided 30% of the electricity, down from approximately 49% in 2008, due to plentiful supplies of low cost natural gas obtained by hydraulic fracturing of tight shale formations.

Coal regions in transition

Some coal-mining regions are highly dependent on coal.

Employment

Some coal miners are concerned their jobs may be lost in the transition.

Bioremediation

The white rot fungus *Trametes versicolor* can grow on and metabolize naturally occurring coal. The bacteria *Diplococcus* has been found to degrade coal, raising its temperature.

Cultural usage

Coal is the official state mineral of Kentucky and the official state rock of Utah; both U.S. states have a historic link to coal mining.

Some cultures hold that children who misbehave will receive only a lump of coal from Santa Claus for Christmas in their christmas stockings instead of presents.

It is also customary and considered lucky in Scotland and the North of England to give coal as a gift on New Year's Day. This occurs as part of First-Footing and represents warmth for the year to come (Coal).

UNIT-11

DISTRIBUTION OF ENERGY RESOURCES- MINERAL OIL

Petroleum is a naturally occurring, yellowish-black liquid found in geological formations beneath the Earth's surface. It is commonly refined into various types of fuels. Components of petroleum are separated using a technique called fractional distillation, i.e. separation of a liquid mixture into fractions differing in boiling point by means of distillation, typically using a fractionating column.

It consists of naturally occurring hydrocarbons of various molecular weights and may contain miscellaneous organic compounds. The name *petroleum* covers both naturally occurring unprocessed **crude oil** and petroleum products that are made up of refined crude oil. A fossil fuel, petroleum is formed when large quantities of dead organisms, mostly zooplankton and algae, are buried underneath sedimentary rock and subjected to both intense heat and pressure.

Petroleum has mostly been recovered by oil drilling (natural petroleum springs are rare). Drilling is carried out after studies of structural geology (at the reservoir scale), sedimentary basin analysis, and reservoir characterisation (mainly in terms of the porosity and permeability of geologic reservoir structures) have been completed. It is refined and separated, most easily by distillation, into a large number of consumer products, from gasoline (petrol) and kerosene to asphalt and chemical reagents used to make plastics, pesticide and pharmaceuticals. Petroleum is used in manufacturing a wide variety of materials, and it is estimated that the world consumes about 95 million barrels each day.

The use of petroleum as fuel is controversial due to its impact on global warming and ocean acidification. Fossil fuel phase-out, including petroleum, need to be completed by the end of 21st century to avoid "severe, pervasive, and irreversible impacts for people and ecosystems", according to the UN's Intergovernmental Panel on Climate Change.

The word *petroleum* comes from Medieval Latin *petroleum* (literally "rock oil"), which comes from Latin *petra*, "rock", (from Ancient Greek: *πέτρα*, romanized: *petra*, "rock") and Latin *oleum*, "oil".

The term was used in the treatise *De Natura Fossilium*, published in 1546 by the German mineralogist Georg Bauer, also known as Georgius Agricola. In the 19th century, the term *petroleum* was often used to refer to mineral oils produced by distillation from mined organic solids such as cannel coal (and later oil shale), and refined oils produced from them; in the United Kingdom, storage (and later transport) of these oils were regulated by a series of Petroleum Acts, from the *Petroleum Act 1863* onwards.

Composition

Petroleum includes not only crude oil, but all liquid, gaseous and solid hydrocarbons. Under surface pressure and temperature conditions, lighter hydrocarbons methane, ethane, propane and butane exist as gases, while pentane and heavier hydrocarbons are in the form of liquids or solids. However, in an underground oil reservoir the proportions of gas, liquid, and solid depend on subsurface conditions and on the phase diagram of the petroleum mixture.

An oil well produces predominantly crude oil, with some natural gas dissolved in it. Because the pressure is lower at the surface than underground, some of the gas will come out of solution and be recovered (or burned) as *associated gas* or *solution gas*. A gas well produces predominantly natural

gas. However, because the underground temperature and pressure are higher than at the surface, the gas may contain heavier hydrocarbons such as pentane, hexane, and heptane in the gaseous state. At surface conditions these will condense out of the gas to form "natural gas condensate", often shortened to *condensate*. Condensate resembles gasoline in appearance and is similar in composition to some volatile light crude oils.

The proportion of light hydrocarbons in the petroleum mixture varies greatly among different oil fields, ranging from as much as 97 percent by weight in the lighter oils to as little as 50 percent in the heavier oils and bitumens.

The hydrocarbons in crude oil are mostly alkanes, cycloalkanes and various aromatic hydrocarbons, while the other organic compounds contain nitrogen, oxygen and sulfur, and trace amounts of metals such as iron, nickel, copper and vanadium. Many oil reservoirs contain live bacteria. The exact molecular composition of crude oil varies widely from formation to formation but the proportion of chemical elements varies over fairly narrow limits as follows:

Composition by weight	
Element	Percent range
Carbon	83 to 85%
Hydrogen	10 to 14%
Nitrogen	0.1 to 2%
Oxygen	0.05 to 1.5%
Sulfur	0.05 to 6.0%
Metals	< 0.1%

Four different types of hydrocarbon molecules appear in crude oil. The relative percentage of each varies from oil to oil, determining the properties of each oil.

Composition by weight		
Hydrocarbon	Average	Range
Alkanes (paraffins)	30%	15 to 60%
Naphthenes	49%	30 to 60%
Aromatics	15%	3 to 30%
Asphaltics	6%	remainder

Crude oil varies greatly in appearance depending on its composition. It is usually black or dark brown (although it may be yellowish, reddish, or even greenish). In the reservoir it is usually found in association with natural gas, which being lighter forms a "gas cap" over the petroleum, and saline water which, being heavier than most forms of crude oil, generally sinks beneath it. Crude oil may also be found in a semi-solid form mixed with sand and water, as in the Athabasca oil sands in Canada, where it is usually referred to as crude bitumen. In Canada, bitumen is considered a sticky, black, tar-like form of crude oil which is so thick and heavy that it must be heated or diluted before it will flow. Venezuela also has large amounts of oil in the Orinoco oil sands, although the hydrocarbons trapped in them are more fluid than in Canada and are usually called extra heavy oil. These oil sands resources are called unconventional oil to distinguish them from oil which can be extracted using traditional oil well methods. Between them, Canada and Venezuela contain an estimated 3.6 trillion barrels (570×10⁹ m³) of bitumen and extra-heavy oil, about twice the volume of the world's reserves of conventional oil.

Petroleum is used mostly, by volume, for refining into fuel oil and gasoline, both important "*primary energy*" sources. 84 percent by volume of the hydrocarbons present in petroleum is converted into energy-rich fuels (petroleum-based fuels), including gasoline, diesel, jet, heating, and other fuel oils, and liquefied petroleum gas. The lighter grades of crude oil produce the best yields of these products, but as the world's reserves of light and medium oil are depleted, oil refineries are increasingly having to process heavy oil and bitumen, and use more complex and expensive methods to produce the products required. Because heavier crude oils have too much carbon and not enough hydrogen, these processes generally involve removing carbon from or adding hydrogen to the molecules, and using fluid catalytic cracking to convert the longer, more complex molecules in the oil to the shorter, simpler ones in the fuels.

Due to its high energy density, easy transportability and relative abundance, oil has become the world's most important source of energy since the mid-1950s. Petroleum is also the raw material for many chemical products, including pharmaceuticals, solvents, fertilizers, pesticides, and plastics; the 16 percent not used for energy production is converted into these other materials. Petroleum is found in porous rock formations in the upper strata of some areas of the Earth's crust. There is also petroleum in oil sands (tar sands). Known oil reserves are typically estimated at around 190 km (1.2 trillion (short scale) barrels) without oil sands, or 595 km (3.74 trillion barrels) with oil sands. Consumption is currently around 84 million barrels (13.4×10 m) per day, or 4.9 km per year, yielding a remaining oil supply of only about 120 years, if current demand remains static.

Classification

The petroleum industry generally classifies crude oil by the geographic location it is produced in (e.g. West Texas Intermediate, Brent, or Oman), its API gravity (an oil industry measure of density), and its sulfur content. Crude oil may be considered *light* if it has low density or *heavy* if it has high density; and it may be referred to as *sweet* if it contains relatively little sulfur or *sour* if it contains substantial amounts of sulfur.

The geographic location is important because it affects transportation costs to the refinery. *Light* crude oil is more desirable than *heavy* oil since it produces a higher yield of gasoline, while *sweet* oil commands a higher price than *sour* oil because it has fewer environmental problems and requires less refining to meet sulfur standards imposed on fuels in consuming countries. Each crude oil has unique molecular characteristics which are revealed by the use of Crude oil assay analysis in petroleum laboratories.

Barrels from an area in which the crude oil's molecular characteristics have been determined and the oil has been classified are used as pricing references throughout the world. Some of the common reference crudes are:

- West Texas Intermediate (WTI), a very high-quality, sweet, light oil delivered at Cushing, Oklahoma for North American oil
- Brent Blend, consisting of 15 oils from fields in the Brent and Ninian systems in the East Shetland Basin of the North Sea. The oil is landed at Sullom Voe terminal in Shetland. Oil production from Europe, Africa and Middle Eastern oil flowing West tends to be priced off this oil, which forms a benchmark

- Dubai-Oman, used as benchmark for Middle East sour crude oil flowing to the Asia-Pacific region
- Tapis (from Malaysia, used as a reference for light Far East oil)
- Minas (from Indonesia, used as a reference for heavy Far East oil)
- The OPEC Reference Basket, a weighted average of oil blends from various OPEC (The Organization of the Petroleum Exporting Countries) countries
- Midway Sunset Heavy, by which heavy oil in California is priced
- Western Canadian Select the benchmark crude oil for emerging heavy, high TAN (acidic) crudes.

There are declining amounts of these benchmark oils being produced each year, so other oils are more commonly what is actually delivered. While the reference price may be for West Texas Intermediate delivered at Cushing, the actual oil being traded may be a discounted Canadian heavy oil—Western Canadian Select— delivered at Hardisty, Alberta, and for a Brent Blend delivered at Shetland, it may be a discounted Russian Export Blend delivered at the port of Primorsk.

Industry

Petroleum is vital to many industries, and is of importance to the maintenance of industrialized civilization itself, and thus is a critical concern to many nations. Oil accounts for a large percentage of the world's energy consumption, ranging from a low of 32 percent for Europe and Asia, up to a high of 53 percent for the Middle East, South and Central America (44%), Africa (41%), and North America (40%). The world at large consumes 30 billion barrels (4.8 km) of oil per year, and the top oil consumers largely consist of developed nations. In fact, 24 percent of the oil consumed in 2004 went to the United States alone, though by 2007 this had dropped to 21 percent of world oil consumed.

In the US, in the states of Arizona, California, Hawaii, Nevada, Oregon and Washington, the Western States Petroleum Association (WSPA) represents companies responsible for producing, distributing, refining, transporting and marketing petroleum. This non-profit trade association was founded in 1907, and is the oldest petroleum trade association in the United States.

Shipping

In the 1950s, shipping costs made up 33 percent of the price of oil transported from the Persian Gulf to the United States, but due to the development of supertankers in the 1970s, the cost of shipping dropped to only 5 percent of the price of Persian oil in the US. Due to the increase of the value of the crude oil during the last 30 years, the share of the shipping cost on the final cost of the delivered commodity was less than 3% in 2010. For example, in 2010 the shipping cost from the Persian Gulf to the US was in the range of 20 \$/t and the cost of the delivered crude oil around 800 \$/t.

Price

After the collapse of the OPEC-administered pricing system in 1985, and a short-lived experiment with netback pricing, oil-exporting countries adopted a market-linked pricing mechanism. First adopted by PEMEX in 1986, market-linked pricing was widely accepted, and by 1988 became and still is the main method for pricing crude oil in international trade. The current reference, or pricing markers, are Brent, WTI, and Dubai/Oman.

Uses

The chemical structure of petroleum is heterogeneous, composed of hydrocarbon chains of different lengths. Because of this, petroleum may be taken to oil refineries and the hydrocarbon chemicals separated by distillation and treated by other chemical processes, to be used for a variety of purposes. The total cost per plant is about 9 billion dollars.

Fuels

The most common distillation fractions of petroleum are fuels. Fuels include (by increasing boiling temperature range):

Common fractions of petroleum as fuels	
Fraction	Boiling range C
Liquefied petroleum gas (LPG)	−40
Butane	−12 to −1
Gasoline/Petrol	−1 to 110
Jet fuel	150 to 205
Kerosene	205 to 260
Fuel oil	205 to 290
Diesel fuel	260 to 315

Other derivatives

Certain types of resultant hydrocarbons may be mixed with other non-hydrocarbons, to create other end products:

- Alkenes (olefins), which can be manufactured into plastics or other compounds
- Lubricants (produces light machine oils, motor oils, and greases, adding viscosity stabilizers as required)
- Wax, used in the packaging of frozen foods, among others
- Sulfur or sulfuric acid. These are useful industrial materials. Sulfuric acid is usually prepared as the acid precursor oleum, a byproduct of sulfur removal from fuels.
- Bulk tar
- Asphalt
- Petroleum coke, used in speciality carbon products or as solid fuel

- Paraffin wax
- Aromatic petrochemicals to be used as precursors in other chemical production

Agriculture

Since the 1940s, agricultural productivity has increased dramatically, due largely to the increased use of energy-intensive mechanization, fertilizers and pesticides.

Use by country

Consumption

According to the US Energy Information Administration (EIA) estimate for 2011, the world consumes 87.421 million barrels of oil each day.

This table orders the amount of petroleum consumed in 2011 in thousand barrels (1000 bbl) per day and in thousand cubic metres (1000 m) per day:

Consuming nation 2011	(1000 bbl/day)	(1000 m/day)	Population in millions	bbl/year per capita	m/year per capita	National production/consumption
United States	18,835.5	2,994.6	314	21.8	3.47	0.51
China	9,790.0	1,556.5	1345	2.7	0.43	0.41
Japan	4,464.1	709.7	127	12.8	2.04	0.03
India	3,292.2	523.4	1198	1	0.16	0.26
Russia	3,145.1	500.0	140	8.1	1.29	3.35
Saudi Arabia (OPEC)	2,817.5	447.9	27	40	6.4	3.64
Brazil	2,594.2	412.4	193	4.9	0.78	0.99
Germany	2,400.1	381.6	82	10.7	1.70	0.06
Canada	2,259.1	359.2	33	24.6	3.91	1.54
South Korea	2,230.2	354.6	48	16.8	2.67	0.02
Mexico	2,132.7	339.1	109	7.1	1.13	1.39
France	1,791.5	284.8	62	10.5	1.67	0.03
Iran (OPEC)	1,694.4	269.4	74	8.3	1.32	2.54
United Kingdom	1,607.9	255.6	61	9.5	1.51	0.93
Italy	1,453.6	231.1	60	8.9	1.41	0.10

Source: US Energy Information Administration

Production

In petroleum industry parlance, *production* refers to the quantity of crude extracted from reserves, not the literal creation of the product.

	Country	Oil Production (bbl/day, 2016)
1	Russia	10,551,497
2	Saudi Arabia (OPEC)	10,460,710
3	United States	8,875,817
4	Iraq (OPEC)	4,451,516
5	Iran (OPEC)	3,990,956
6	China, People's Republic of	3,980,650
7	Canada	3,662,694
8	United Arab Emirates (OPEC)	3,106,077
9	Kuwait (OPEC)	2,923,825
10	Brazil	2,515,459
11	Venezuela (OPEC)	2,276,967
12	Mexico	2,186,877
13	Nigeria (OPEC)	1,999,885
14	Angola (OPEC)	1,769,615
15	Norway	1,647,975
16	Kazakhstan	1,595,199
17	Qatar (OPEC)	1,522,902
18	Algeria (OPEC)	1,348,361
19	Oman	1,006,841
20	United Kingdom	939,760

Exportation

Canadian statistics are complicated by the fact it is both an importer and exporter of crude oil, and refines large amounts of oil for the U.S. market. It is the leading source of U.S. imports of oil and products, averaging 2,500,000 bbl/d (400,000 m/d) in August 2007.

Total world production/consumption (as of 2005) is approximately 84 million barrels per day (13,400,000 m/d).

Importation

In order of net imports in 2011, 2009 and 2006 in thousand bbl/d and thousand m/d:

#	Importing nation	10bbl/day (2011)	10m/day (2011)	10bbl/day (2009)	10m/day (2009)	10bbl/day (2006)	10m/day (2006)
1	United States	8,728	1,388	9,631	1,531	12,220	1,943
2	China	5,487	872	4,328	688	3,438	547
3	Japan	4,329	688	4,235	673	5,097	810
4	India	2,349	373	2,233	355	1,687	268
5	Germany	2,235	355	2,323	369	2,483	395
6	South Korea	2,170	345	2,139	340	2,150	342
7	France	1,697	270	1,749	278	1,893	301

8	Spain	1,346	214	1,439	229	1,555	247
9	Italy	1,292	205	1,381	220	1,558	248
10	Singapore	1,172	186	916	146	787	125
11	Republic of China (Taiwan)	1,009	160	944	150	942	150
12	Netherlands	948	151	973	155	936	149
13	Turkey	650	103	650	103	576	92
14	Belgium	634	101	597	95	546	87
15	Thailand	592	94	538	86	606	96

Source: US Energy Information Administration

Non-producing consumers

#	Consuming nation	(bbl/day)	(m/day)
1	Japan	5,578,000	886,831
2	Germany	2,677,000	425,609
3	South Korea	2,061,000	327,673
4	France	2,060,000	327,514
5	Italy	1,874,000	297,942
6	Spain	1,537,000	244,363
7	Netherlands	946,700	150,513
8	Turkey	575,011	91,663

Source: CIA World Factbook

Environmental effects

Because petroleum is a naturally occurring substance, its presence in the environment need not be the result of human causes such as accidents and routine activities (seismic exploration, drilling, extraction, refining and combustion). Phenomena such as seeps and tar pits are examples of areas that petroleum affects without man's involvement. Regardless of source, petroleum's effects when released into the environment are similar.

Ocean acidification

Ocean acidification is the increase in the acidity of the Earth's oceans caused by the uptake of carbon dioxide (CO₂) from the atmosphere. This increase in acidity inhibits all marine life – having a greater impact on smaller organisms as well as shelled organisms.

Global warming

When burned, petroleum releases carbon dioxide, a greenhouse gas. Along with the burning of coal, petroleum combustion may be the largest contributor to the increase in atmospheric CO₂. Atmospheric CO₂ has risen over the last 150 years to current levels of over 390 ppmv, from the 180 – 300 ppmv of the prior 800 thousand years. This rise in temperature may have reduced the Arctic ice cap to 1,100,000 sq mi (2,800,000 km), smaller than ever recorded. Because of this melt, more oil reserves have been revealed. About 13 percent of the world's undiscovered oil resides in the Arctic.

Extraction

Oil extraction is simply the removal of oil from the reservoir (oil pool). Oil is often recovered as a water-in-oil emulsion, and specialty chemicals called demulsifiers are used to separate the oil from water. Oil extraction is costly and sometimes environmentally damaging. Offshore exploration and extraction of oil disturbs the surrounding marine environment.

Oil spills

Crude oil and refined fuel spills from tanker ship accidents have damaged natural ecosystems in Alaska, the Gulf of Mexico, the Galápagos Islands, France and many other places.

The quantity of oil spilled during accidents has ranged from a few hundred tons to several hundred thousand tons (e.g., Deepwater Horizon oil spill, SS Atlantic Empress, Amoco Cadiz). Smaller spills have already proven to have a great impact on ecosystems, such as the *Exxon Valdez* oil spill.

Oil spills at sea are generally much more damaging than those on land, since they can spread for hundreds of nautical miles in a thin oil slick which can cover beaches with a thin coating of oil. This can kill sea birds, mammals, shellfish and other organisms it coats. Oil spills on land are more readily containable if a makeshift earth dam can be rapidly bulldozed around the spill site before most of the oil escapes, and land animals can avoid the oil more easily.

Control of oil spills is difficult, requires ad hoc methods, and often a large amount of manpower. The dropping of bombs and incendiary devices from aircraft on the SS *Torrey Canyon* wreck produced poor results; modern techniques would include pumping the oil from the wreck, like in the *Prestige* oil spill or the *Erika* oil spill.

Though crude oil is predominantly composed of various hydrocarbons, certain nitrogen heterocyclic compounds, such as pyridine, picoline, and quinoline are reported as contaminants associated with crude oil, as well as facilities processing oil shale or coal, and have also been found at legacy wood treatment sites. These compounds have a very high water solubility, and thus tend to dissolve and move with water. Certain naturally occurring bacteria, such as *Micrococcus*, *Arthrobacter*, and *Rhodococcus* have been shown to degrade these contaminants.

Tarballs

A tarball is a blob of crude oil (not to be confused with tar, which is a man-made product derived from pine trees or refined from petroleum) which has been weathered after floating in the ocean. Tarballs are an aquatic pollutant in most environments, although they can occur naturally, for example in the Santa Barbara Channel of California or in the Gulf of Mexico off Texas. Their concentration and features have been used to assess the extent of oil spills. Their composition can be used to identify their sources of origin, and tarballs themselves may be dispersed over long distances by deep sea currents. They are slowly decomposed by bacteria, including *Chromobacterium violaceum*, *Cladosporium resinae*, *Bacillus submarinus*, *Micrococcus varians*, *Pseudomonas aeruginosa*, *Candida marina* and *Saccharomyces estuari*.

Whales

James S. Robbins has argued that the advent of petroleum-refined kerosene saved some species of great whales from extinction by providing an inexpensive substitute for whale oil, thus eliminating the economic imperative for open-boat whaling.

Alternatives

In the United States in 2007 about 70 percent of petroleum was used for transportation (e.g. gasoline, diesel, jet fuel), 24 percent by industry (e.g. production of plastics), 5 percent for residential and commercial uses, and 2 percent for electricity production. Outside of the US, a higher proportion of petroleum tends to be used for electricity.

Vehicle fuels

Petroleum-based vehicle fuels can be replaced by either alternative fuels, or other methods of propulsion such as electric or nuclear.

Alternative fuel vehicles refers to both:

- Vehicles that use alternative fuels used in standard or modified internal combustion engines such as natural gas vehicles, neat ethanol vehicles, flexible-fuel vehicles, biodiesel-powered vehicles, propane autogas, and hydrogen vehicles.
- Vehicles with advanced propulsion systems that reduce or substitute petroleum use such as battery electric vehicles, plug-in hybrid electric vehicles, hybrid electric vehicles, and hydrogen fuel cell vehicles.

Industrial oils

Biological feed stocks do exist for industrial uses such as Bioplastic production.

Electricity

In oil producing countries with little refinery capacity, oil is sometimes burned to produce electricity. Renewable energy technologies such as solar power, wind power, micro hydro, biomass and biofuels are used, but the primary alternatives remain large-scale hydroelectricity, nuclear and coal-fired generation.

Future Production

Consumption in the twentieth and twenty-first centuries has been abundantly pushed by automobile sector growth. The 1985–2003 oil glut even fueled the sales of low fuel economy vehicles in OECD countries. The 2008 economic crisis seems to have had some impact on the sales of such vehicles; still, in 2008 oil consumption showed a small increase.

In 2016 Goldman Sachs predicted lower demand for oil due to emerging economies concerns, especially China. The BRICS (Brasil, Russia, India, China, South Africa) countries might also kick in, as China briefly was the first automobile market in December 2009. The immediate outlook still hints upwards. In the long term, uncertainties linger; the OPEC believes that the OECD countries will push low consumption policies at some point in the future; when that happens, it will definitely curb oil sales, and both OPEC and the Energy Information Administration (EIA) kept lowering their 2020 consumption estimates during the past five years. A detailed review of International Energy Agency oil projections have revealed that revisions of world oil production, price and investments have been motivated by a combination of demand and supply factors. All together, Non-OPEC conventional projections have been fairly stable the last 15 years, while downward revisions were mainly allocated to OPEC. Recent upward revisions are primarily a result of US tight oil.

Production will also face an increasingly complex situation; while OPEC countries still have large reserves at low production prices, newly found reservoirs often lead to higher prices; offshore giants such as Tupi, Guara and Tiber demand high investments and ever-increasing technological abilities. Subsalt reservoirs such as Tupi were unknown in the twentieth century, mainly because the industry was unable to probe them. Enhanced Oil Recovery (EOR) techniques (example: DaQing, China) will continue to play a major role in increasing the world's recoverable oil.

The expected availability of petroleum resources has always been around 35 years or even less since the start of the modern exploration. The oil constant, an insider pun in the German industry, refers to that effect.

Peak oil

Peak oil is a term applied to the projection that future petroleum production (whether for individual oil wells, entire oil fields, whole countries, or worldwide production) will eventually peak and then decline at a similar rate to the rate of increase before the peak as these reserves are exhausted. The peak of oil discoveries was in 1965, and oil production per year has surpassed oil discoveries every year since 1980. However, this does not mean that potential oil production has surpassed oil demand.

Hubbert applied his theory to accurately predict the peak of U.S. conventional oil production at a date between 1966 and 1970. This prediction was based on data available at the time of his publication in 1956. In the same paper, Hubbert predicts world peak oil in "half a century" after his publication, which would be 2006.

It is difficult to predict the oil peak in any given region, due to the lack of knowledge and/or transparency in accounting of global oil reserves. Based on available production data, proponents have previously predicted the peak for the world to be in years 1989, 1995, or 1995–2000. Some of these predictions date from before the recession of the early 1980s, and the consequent reduction in global consumption, the effect of which was to delay the date of any peak by several years. Just as the 1971 U.S. peak in oil production was only clearly recognized after the fact, a peak in world production will be difficult to discern until production clearly drops off. The peak is also a moving

target as it is now measured as "liquids", which includes synthetic fuels, instead of just conventional oil.

The International Energy Agency (IEA) said in 2010 that production of conventional crude oil had peaked in 2006 at 70 MBBL/d, then flattened at 68 or 69 thereafter. Since virtually all economic sectors rely heavily on petroleum, peak oil, if it were to occur, could lead to a "partial or complete failure of markets". In the mid-2000s, widespread fears of an imminent peak led to the "peak oil movement," in which over one hundred thousand Americans prepared, individually and collectively, for the "post-carbon" future.

Unconventional oil

Unconventional oil is petroleum produced or extracted using techniques other than the conventional methods. The calculus for peak oil has changed with the introduction of unconventional production methods. In particular, the combination of horizontal drilling and hydraulic fracturing has resulted in a significant increase in production from previously uneconomic plays. Analysts expected that \$150 billion would be spent on further developing North American tight oil fields in 2015. The large increase in tight oil production is one of the reasons behind the price drop in late 2014. Certain rock strata contain hydrocarbons but have low permeability and are not thick from a vertical perspective. Conventional vertical wells would be unable to economically retrieve these hydrocarbons. Horizontal drilling, extending horizontally through the strata, permits the well to access a much greater volume of the strata. Hydraulic fracturing creates greater permeability and increases hydrocarbon flow to the wellbore (Petroleum).

UNIT-12

CRISIS, CONSERVATION AND MANAGEMENT OF RESOURCE

Resource depletion is the consumption of a resource faster than it can be replenished. Natural resources are commonly divided between renewable resources and non-renewable resources (see also mineral resource classification). Use of either of these forms of resources beyond their rate of replacement is considered to be resource depletion. The value of a resource is a direct result of its availability in nature and the cost of extracting the resource, the more a resource is depleted the more the value of the resource increases. There are several types of resource depletion the most known being; Aquifer depletion, deforestation, mining for fossil fuels and minerals, pollution or contamination of resources, slash-and-burn agricultural practices, Soil erosion, and overconsumption, excessive or unnecessary use of resources.

Resource depletion is most commonly used in reference to farming, fishing, mining, water usage, and consumption of fossil fuels. Depletion of wildlife populations is called *defaunation*.

Depletion accounting

In an effort to offset the depletion of resources theorists have come up with depletion accounting or better known as 'green accounting'. Depletion accounting aims to account for nature's value on an equal footing with the market economy. Resource depletion accounting uses data provided from countries to estimate the adjustments needed due to their use and depletion of the natural capital available to them. Natural capital are natural resources such as mineral deposits or timber stocks. Depletion accounting factors in several different influences such as the number of years until resource exhaustion, the cost of resource extraction and the demand of the resource. Resource extraction industries make up a large part of the economic activity in developing countries, this in turn leads to higher levels of resource depletion and environmental degradation in developing countries. Theorists argue that implementation of resource depletion accounting is necessary in developing countries. Depletion accounting also seeks to measure the social value of natural resources and ecosystems. Measurement of social value is sought through ecosystem services which are defined as the benefits of nature to households, communities and economies.

Importance

There are many different groups interested in depletion accounting. Environmentalists are interested in depletion accounting as a way to track the use of natural resources over time, hold governments accountable or to compare their environmental conditions to those of another country. Economists want to measure resource depletion to understand how financially reliant countries or corporations are on non-renewable resources, whether this use can be sustained and the financial drawbacks of switching to renewable resources in light of the depleting resources.

Issues

Depletion accounting is complex to implement as nature is not as quantifiable like cars, houses or bread. For depletion accounting to work, appropriate units of natural resources must be established so that natural resources can be viable in the market economy. The main issues that arise when trying to do so are, determining a suitable unit of account, deciding how to deal with "collective" nature of a complete ecosystem, delineating the borderline of the ecosystem and defining the extent of possible duplication when the resource interacts in more than one ecosystem. Some economists want to include measurement of the benefits arising from public goods provided by nature, but currently there are no

market indicators of value. Globally, environmental economics has not been able to provide a consensus of measurement units of nature's services.

Mineral depletion

Minerals are needed to provide food, clothing, and housing. A United States Geological Survey (USGS) study found a significant long-term trend over the 20th century for non-renewable resources such as minerals to supply a greater proportion of the raw material inputs to the non-fuel, non-food sector of the economy; an example is the greater consumption of crushed stone, sand, and gravel used in construction.

Large-scale exploitation of minerals began in the Industrial Revolution around 1760 in England and has grown rapidly ever since. Technological improvements have allowed humans to dig deeper and access lower grades and different types of ore over that time. Virtually all basic industrial metals (copper, iron, bauxite, etc.), as well as rare earth minerals, face production output limitations from time to time, because supply involves large up-front investments and is therefore slow to respond to rapid increases in demand.

Minerals projected by some to enter production decline during the next 20 years:

- Gasoline (2023)
- Copper (2024). Data from the United States Geological Survey (USGS) suggest that it is very unlikely that copper production will peak before 2040.
- Zinc. Developments in hydrometallurgy have transformed non-sulfide zinc deposits (largely ignored until now) into large low cost reserves.

Minerals projected by some to enter production decline during the present century:

- Aluminium (2057)
- Coal (2060)
- Iron (2068)

Such projections may change, as new discoveries are made and typically misinterpret available data on Mineral Resources and Mineral Reserves.

Oil

Peak oil is the period when the maximum rate of global petroleum extraction is reached, after which the rate of production will undergo a long-term decline. The 2005 Hirsch report concluded that the decreased supply combined with increasing demand will significantly increase the worldwide prices of petroleum derived products, and that most significant will be the availability and price of liquid fuel for transportation.

The Hirsch report, funded by United States Department of Energy, concluded that “The peaking of world oil production presents the U. S. and the world with an unprecedented risk management problem. As peaking is approached, liquid fuel prices and price volatility will increase dramatically, and, without timely mitigation, the economic, social, and political costs will be unprecedented. Viable mitigation options exist on both the supply and demand sides, but to have substantial impact, they must be initiated more than a decade in advance of peaking.”

Deforestation

Deforestation is the clearing of forests by cutting or burning of trees and plants in a forested area. As a result of deforestation, presently about one half of the forests that once covered Earth have been destroyed. It occurs for many different reasons, and it has several negative implications on the atmosphere and the quality of the land in and surrounding the forest.

Causes

One of the main causes of deforestation is clearing forests for agricultural reasons. As the population of developing areas, especially near rainforests, increases, the need for land for farming becomes more and more important. For most people, a forest has no value when its resources are not being used, so the incentives to deforest these areas outweigh the incentives to preserve the forests. For this reason, the economic value of the forests is very important for the developing countries.

Environmental impact

Because deforestation is so extensive, it has made several significant impacts on the environment, including carbon dioxide in the atmosphere, changing the water cycle, an increase in soil erosion, and a decrease in biodiversity. Deforestation is often cited as a contributor to global warming. Because trees and plants remove carbon dioxide and emit oxygen into the atmosphere, the reduction of forests contribute to about 12% of anthropogenic carbon dioxide emissions. One of the most pressing issues that deforestation creates is soil erosion. The removal of trees causes higher rates of erosion, increasing risks of landslides, which is a direct threat to many people living close to deforested areas. As forests get destroyed, so does the habitat for millions of animals. It is estimated that 80% of the world's known biodiversity lives in the rainforests, and the destruction of these rainforests is accelerating extinction at an alarming rate.

Controlling deforestation

The United Nations and the World Bank created programs such as Reducing Emissions from Deforestation and Forest Degradation (REDD), which works especially with developing countries to use subsidies or other incentives to encourage citizens to use the forest in a more sustainable way. In addition to making sure that emissions from deforestation are kept to a minimum, an effort to educate people on sustainability and helping them to focus on the long-term risks is key to the success of these programs. The New York Declaration on Forests and its associated actions promotes reforestation, which is being encouraged in many countries in an attempt to repair the damage that deforestation has done.

Wetlands

Wetlands are ecosystems that are often saturated by enough surface or groundwater to sustain vegetation that is usually adapted to saturated soil conditions, such as cattails, bulrushes, red maples, wild rice, blackberries, cranberries, and peat moss. Because some varieties of wetlands are rich in minerals and nutrients and provide many of the advantages of both land and water environments they contain diverse species and provide a distinct basis for the food chain. Wetland habitats contribute to environmental health and biodiversity. Wetlands are a nonrenewable resource on a human timescale and in some environments cannot ever be renewed. Recent studies indicate that global loss of wetlands could be as high as 87% since 1700 AD, with 64% of wetland loss occurring since 1900. Some loss of wetlands resulted from natural causes such as erosion, sedimentation, subsidence, and a rise in the sea level.

Wetlands provide environmental services for:

1. Food and habitat
2. Improving water quality
3. Commercial fishing
4. Floodwater reduction
5. Shoreline stabilization
6. Recreation

Resources in wetlands

Some of the world's most successful agricultural areas are wetlands which have been drained and converted to farmland for large-scale agriculture. Large-scale draining of wetlands also occurs for real estate development and urbanization. In contrast in some cases wetlands are also flooded to be converted to recreational lakes or hydro-power generation. In some countries ranchers have also moved their property onto wetlands for grazing due to the nutrient rich vegetation. Wetlands in Southern America also prove a fruitful resource for poachers, as animals with valuable hides such as jaguars, maned wolves, caimans and snakes are drawn to wetlands. The effect of the removal of large predators is still unknown in South African wetlands.

Humans benefit from wetlands in indirect ways as well. Wetlands act as natural water filters, when runoff from either natural or man-made processes pass through, wetlands can have a neutralizing effect. If a wetland is in between an agricultural zone and a freshwater ecosystem, fertilizer runoff will be absorbed by the wetland and used to fuel the slow processes that occur there. By the time the water reaches the freshwater ecosystem there won't be enough fertilizer to cause destructive algal blooms that poison freshwater ecosystems.

Non-natural causes of wetland degradation

- Hydrologic alteration
 - o drainage
 - o dredging
 - o stream channelization
 - o ditching
 - o levees
 - o deposition of fill material
 - o stream diversion
 - o groundwater drainage
 - o impoundment
- Urbanization and urban development
- Marinas/boats

- Industrialization and industrial development
- Agriculture
- Silviculture/Timber harvest
- Mining
- Atmospheric deposition

To preserve the resources extracted from wetlands, current strategies are to rank wetlands and prioritize the conservation of wetlands with more environmental services, create more efficient irrigation for wetlands being used for agriculture and restricting access to wetlands by tourists.

Groundwater

Water is an essential resource needed to survive everyday life. Historically, water has had a profound influence on a nation's prosperity and success around the world. Groundwater is water that is in saturated zones underground, the upper surface of the saturated zone is called the water table. Groundwater is held in the pores and fractures of underground materials like sand, gravel and other rock, these rock materials are called aquifers. Groundwater can either flow naturally out of rock materials or can be pumped out. Groundwater supplies wells and aquifers for private, agricultural, and public use and is used by more than a third of the world's population every day for their drinking water. Globally there is 22.6 million cubic kilometers of groundwater available and only .35 million of that is renewable.

Groundwater as a non-renewable resource

Groundwater is considered to be a non-renewable resource because less than six percent of the water around the world is replenished and renewed on a human timescale of 50 years. People are already using non-renewable water that is thousands of years old, in areas like Egypt they are using water that may have been renewed a million years ago which is not renewable on human timescales. Of the groundwater used for agriculture 16 to 33% is non-renewable. It is estimated that since the 1960's groundwater extraction has more than doubled, which has increased groundwater depletion. Due to this increase in depletion, in some of the most depleted areas use of groundwater for irrigation has become impossible or cost prohibitive.

Environmental impacts

Overusing groundwater, old or young can lower subsurface water levels and dry up streams, which could have a huge effect on ecosystems on the surface. When the most easily recoverable fresh groundwater is removed this leaves a residual with inferior water quality. This is in part from induced leakage from the land surface, confining layers or adjacent aquifers that contain saline or contaminated water. Worldwide the magnitude of groundwater depletion from storage may be so large as to constitute a measurable contributor to sea-level rise.

Mitigation

Currently, societies respond to water-resource depletion by shifting management objectives from location and developing new supplies to augmenting conserving and reallocation of existing supplies. There are two different perspectives to groundwater depletion, the first is that depletion is considered literally and simply as a reduction in the volume of water in the saturated zone, regardless

of water quality considerations. A second perspective views depletion as a reduction in the usable volume of fresh groundwater in storage.

Augmenting supplies can mean improving water quality or increasing water quantity. Depletion due to quality considerations can be overcome by treatment, whereas large volume metric depletion can only be alleviated by decreasing discharge or increasing recharge. Artificial recharge of storm flow and treated municipal wastewater, has successfully reversed groundwater declines. In the future improved infiltration and recharge technologies will be more widely used to maximize the capture of runoff and treated wastewater.

Renewable resources

Renewable energy can be collected from renewable resources. The two main sources of renewable energy are solar energy and wind power. The government and scientists are researching and looking upon alternatives to replace the depleting nonrenewable resources. Japan and the U.S. are leading in the department of selling and manufacturing solar powered utilities (Resource depletion).

Environmental resource management is the management of the interaction and impact of human societies on the environment. It is not, as the phrase might suggest, the management of the environment itself. Environmental resources management aims to ensure that ecosystem services are protected and maintained for future human generations, and also maintain ecosystem integrity through considering ethical, economic, and scientific (ecological) variables. Environmental resource management tries to identify factors affected by conflicts that rise between meeting needs and protecting resources. It is thus linked to environmental protection, sustainability and integrated landscape management.

Significance

Environmental resource management is an issue of increasing concern, as reflected in its prevalence in seminal texts influencing global sociopolitical frameworks such as the Brundtland Commission's Our Common Future, which highlighted the integrated nature of environment and international development and the Worldwatch Institute's annual State of the World reports.

The environment determines the nature of people, animals, plants, and places around the Earth, affecting behaviour, religion, culture and economic practices.

Scope

Environmental resource management can be viewed from a variety of perspectives. It involves the management of all components of the biophysical environment, both living (biotic) and non-living (abiotic), and the relationships among all living species and their habitats. The environment also involves the relationships of the human environment, such as the social, cultural and economic environment, with the biophysical environment. The essential aspects of environmental resource management are ethical, economical, social, and technological. These underlie principles and help make decisions.

The concept of environmental determinism, probabilism and possibilism are significant in the concept of environmental resource management.

Environmental resource management covers many areas in science, including geography, biology, social sciences, political sciences, public policy, ecology, physics, chemistry, sociology, psychology, and physiology.

Aspects

Ethical

Environmental resource management strategies are intrinsically driven by conceptions of human-nature relationships. Ethical aspects involve the cultural and social issues relating to the environment, and dealing with changes to it. "All human activities take place in the context of certain types of relationships between society and the bio-physical world (the rest of nature)," and so, there is a great significance in understanding the ethical values of different groups around the world. Broadly speaking, two schools of thought exist in environmental ethics: Anthropocentrism and Ecocentrism, each influencing a broad spectrum of environmental resource management styles along a continuum. These styles perceive "...different evidence, imperatives, and problems, and prescribe different solutions, strategies, technologies, roles for economic sectors, culture, governments, and ethics, etc."

Anthropocentrism

Anthropocentrism, "...an inclination to evaluate reality exclusively in terms of human values," is an ethic reflected in the major interpretations of Western religions and the dominant economic paradigms of the industrialised world. Anthropocentrism looks at nature as existing solely for the benefit of humans, and as a commodity to use for the good of humanity and to improve human quality of life. Anthropocentric environmental resource management is therefore not the conservation of the environment solely for the environment's sake, but rather the conservation of the environment, and ecosystem structure, for humans' sake.

Ecocentrism

Ecocentrists believe in the intrinsic value of nature while maintaining that human beings must use and even exploit nature to survive and live. It is this fine ethical line that ecocentrists navigate between fair use and abuse. At an extreme of the ethical scale, ecocentrism includes philosophies such as ecofeminism and deep ecology, which evolved as a reaction to dominant anthropocentric paradigms. "In its current form, it is an attempt to synthesize many old and some new philosophical attitudes about the relationship between nature and human activity, with particular emphasis on ethical, social, and spiritual aspects that have been downplayed in the dominant economic worldview."

Economics

The economy functions within, and is dependent upon goods and services provided by natural ecosystems. The role of the environment is recognized in both classical economics and neoclassical economics theories, yet the environment was a lower priority in economic policies from 1950 to 1980 due to emphasis from policy makers on economic growth. With the prevalence of environmental problems, many economists embraced the notion that, "If environmental sustainability must coexist for economic sustainability, then the overall system must [permit] identification of an equilibrium between the environment and the economy." As such, economic policy makers began to incorporate the functions of the natural environment—or natural capital — particularly as a sink for wastes and for the provision of raw materials and amenities.

Debate continues among economists as to how to account for natural capital, specifically whether resources can be replaced through knowledge and technology, or whether the environment is a closed system that cannot be replenished and is finite. Economic models influence environmental resource management, in that management policies reflect beliefs about natural capital scarcity. For someone who believes natural capital is infinite and easily substituted, environmental management is irrelevant to the economy. For example, economic paradigms based on neoclassical models of closed economic systems are primarily concerned with resource scarcity, and thus prescribe legalizing the environment as an economic externality for an environmental resource management strategy. This approach has often been termed 'Command-and-control'. Colby has identified trends in the development of economic paradigms, among them, a shift towards more ecological economics since the 1990s.

Ecology

"The pairing of significant uncertainty about the behaviour and response of ecological systems with urgent calls for near-term action constitutes a difficult reality, and a common lament" for many environmental resource managers. Scientific analysis of the environment deals with several dimensions of ecological uncertainty. These include: *structural uncertainty* resulting from the misidentification, or lack of information pertaining to the relationships between ecological variables; *parameter uncertainty* referring to "uncertainty associated with parameter values that are not known precisely but can be assessed and reported in terms of the likelihood...of experiencing a defined range of outcomes"; and *stochastic uncertainty* stemming from chance or unrelated factors. Adaptive management is considered a useful framework for dealing with situations of high levels of uncertainty though it is not without its detractors.

A common scientific concept and impetus behind environmental resource management is carrying capacity. Simply put, carrying capacity refers to the maximum number of organisms a particular resource can sustain. The concept of carrying capacity, whilst understood by many cultures over history, has its roots in Malthusian theory. An example is visible in the EU Water Framework Directive. However, "it is argued that Western scientific knowledge ... is often insufficient to deal with the full complexity of the interplay of variables in environmental resource management. These concerns have been recently addressed by a shift in environmental resource management approaches to incorporate different knowledge systems including traditional knowledge, reflected in approaches such as adaptive co-management community-based natural resource management and transitions management among others.

Sustainability

Sustainability in environmental resource management involves managing economic, social, and ecological systems both within and outside an organizational entity so it can sustain itself and the system it exists in. In context, sustainability implies that rather than competing for endless growth on a finite planet, development improves quality of life without necessarily consuming more resources. Sustainably managing environmental resources requires organizational change that instills sustainability values that portrays these values outwardly from all levels and reinforces them to surrounding stakeholders. The end result should be a symbiotic relationship between the sustaining organization, community, and environment.

Many drivers compel environmental resource management to take sustainability issues into account. Today's economic paradigms do not protect the natural environment, yet they deepen human dependency on biodiversity and ecosystem services. Ecologically, massive environmental degradation and climate change threaten the stability of ecological systems that humanity depends on. Socially, an increasing gap between rich and poor and the global North-South divide denies many access to basic human needs, rights, and education, leading to further environmental destruction. The planet's unstable condition is caused by many anthropogenic sources. As an exceptionally powerful contributing factor to social and environmental change, the modern organisation has the potential to apply environmental resource management with sustainability principals to achieve highly effective outcomes. To achieve sustainable development with environmental resource management an organisation should work within sustainability principles, including social and environmental accountability, long-term planning; a strong, shared vision; a holistic focus; devolved and consensus decision making; broad stakeholder engagement and justice; transparency measures; trust; and flexibility.

Current paradigm shifts

To adjust to today's environment of quick social and ecological changes, some organizations have begun to experiment with new tools and concepts. Those that are more traditional and stick to hierarchical decision making have difficulty dealing with the demand for lateral decision making that supports effective participation. Whether it be a matter of ethics or just strategic advantage organizations are internalizing sustainability principles. Some of the world's largest and most profitable corporations are shifting to sustainable environmental resource management: Ford, Toyota, BMW, Honda, Shell, Du Pont, Statoil, Swiss Re, Hewlett-Packard, and Unilever, among others. An extensive study by the Boston Consulting Group reaching 1,560 business leaders from diverse regions, job positions, expertise in sustainability, industries, and sizes of organizations, revealed the many benefits of sustainable practice as well as its viability.

It is important to note that though sustainability of environmental resource management has improved, corporate sustainability, for one, has yet to reach the majority of global companies operating in the markets. The three major barriers to preventing organizations to shift towards sustainable practice with environmental resource management are not understanding what sustainability is; having difficulty modeling an economically viable case for the switch; and having a flawed execution plan, or a lack thereof. Therefore, the most important part of shifting an organization to adopt sustainability in environmental resource management would be to create a shared vision and understanding of what sustainability is for that particular organization, and to clarify the business case.

Stakeholders

Public sector

The public sector comprises the general government sector plus all public corporations including the central bank. In environmental resource management the public sector is responsible for administering natural resource management and implementing environmental protection legislation. The traditional role of the public sector in environmental resource management is to provide professional judgement through skilled technicians on behalf of the public. With the increase of intractable environmental problems, the public sector has been led to examine alternative paradigms for managing environmental resources. This has resulted in the public sector working collaboratively with other sectors (including other governments, private and civil) to encourage sustainable natural resource management behaviours.

Private sector

The private sector comprises private corporations and non-profit institutions serving households. The private sector's traditional role in environmental resource management is that of the recovery of natural resources. Such private sector recovery groups include mining (minerals and petroleum), forestry and fishery organisations. Environmental resource management undertaken by the private sectors varies dependent upon the resource type, that being renewable or non-renewable and private and common resources (also see Tragedy of the Commons). Environmental managers from the private sector also need skills to manage collaboration within a dynamic social and political environment.

Civil society

Civil society comprises associations in which societies voluntarily organise themselves into and which represent a wide range of interests and ties. These can include community-based organisations, indigenous peoples' organisations and non-government organisations (NGO). Functioning through strong public pressure, civil society can exercise their legal rights against the implementation of resource management plans, particularly land management plans. The aim of civil society in environmental resource management is to be included in the decision-making process by means of public participation. Public participation can be an effective strategy to invoke a sense of social responsibility of natural resources.

Tools

As with all management functions, effective management tools, standards and systems are required. An environmental management standard or system or protocol attempts to reduce environmental impact as measured by some objective criteria. The ISO 14001 standard is the most widely used standard for environmental risk management and is closely aligned to the European Eco-Management and Audit Scheme (EMAS). As a common auditing standard, the ISO 19011 standard explains how to combine this with quality management.

Other environmental management systems (EMS) tend to be based on the ISO 14001 standard and many extend it in various ways:

- The Green Dragon Environmental Management Standard is a five-level EMS designed for smaller organisations for whom ISO 14001 may be too onerous and for larger organisations who wish to implement ISO 14001 in a more manageable step-by-step approach,
- BS 8555 is a phased standard that can help smaller companies move to ISO 14001 in six manageable steps,
- The Natural Step focuses on basic sustainability criteria and helps focus engineering on reducing use of materials or energy use that is unsustainable in the long term,
- Natural Capitalism advises using accounting reform and a general biomimicry and industrial ecology approach to do the same thing,
- US Environmental Protection Agency has many further terms and standards that it defines as appropriate to large-scale EMS,

- The UN and World Bank has encouraged adopting a "natural capital" measurement and management framework,
- The European Union Eco-Management and Audit Scheme (EMAS).

Other strategies exist that rely on making simple distinctions rather than building top-down management "systems" using performance audits and full cost accounting. For instance, Ecological Intelligent Design divides products into consumables, service products or durables and unsaleables — toxic products that no one should buy, or in many cases, do not realize they are buying. By eliminating the unsaleables from the comprehensive outcome of any purchase, better environmental resource management is achieved without *systems*.

Recent successful cases have put forward the notion of *integrated management*. It shares a wider approach and stresses out the importance of interdisciplinary assessment. It is an interesting notion that might not be adaptable to all cases (Resource depletion).

UNIT-13

MAJOR ECONOMIC ACTIVITIES- PRIMARY, SECONDARY AND TERTIARY ACTIVITIES

One classical breakdown of economic activity distinguishes three sectors:

- Primary: involves the retrieval and production of raw materials, such as corn, coal, wood and iron. (A coal miner, farmer or fisherman would be workers in the primary sector.)
- Secondary: involves the transformation of raw or intermediate materials into goods e.g. manufacturing steel into cars, or textiles into clothing. (A builder and a dressmaker would be workers in the secondary sector.)
- Tertiary: involves the supplying of services to consumers and businesses, such as baby-sitting, cinema and banking. (A shopkeeper and an accountant would be workers in the tertiary sector.)

In the 20th century, economists began to suggest that traditional tertiary services could be further distinguished from "quaternary" and quinary service sectors. Economic activity in the hypothetical quaternary sector comprises information- and knowledge-based services, while quinary services include industry related to human services and hospitality.

Historic evolution

An economy may include several sectors (also called "industries") that evolved in successive phases:

- The ancient economy built mainly on the basis of subsistence farming.
- The industrial revolution lessened the role of subsistence farming, converting land-use to more extensive and monocultural forms of agriculture over the last three centuries. Economic growth took place mostly in the mining, construction and manufacturing industries.
- In the economies of modern consumer societies, services, finance, and technology – the knowledge economy – play an increasingly significant role.

Even in modern times, developing countries tend to rely more on the first two sectors, in contrast to developed countries.

The primary sector of the economy includes any industry involved in the extraction and collection of natural resources; such as farming, forestry, mining and fishing.

Primary sector of the economy

The primary sector tends to make up a larger portion of the economy in developing countries than it does in developed countries. For example, animal husbandry is relatively more common in countries in Africa than it is in Japan.

Mining in 19th-century South Wales provides a case study of how an economy can come to rely on one form of activity.

In developed countries primary industry has become more technologically advanced - witness for instance the mechanization of farming as opposed to hand-picking and -planting. More developed economies may invest additional capital in primary means of production. As an example, in

the United States' corn belt, combine harvesters pick the corn, and sprayers spray large amounts of insecticides, herbicides and fungicides, producing a higher yield than is possible using less capital-intensive techniques. These technological advances and investment allow the primary sector to employ a smaller workforce - in this way, developed countries tend to have a smaller percentage of their workforce involved in primary activities, instead having a higher percentage involved in the secondary and tertiary sectors.

Developed countries are allowed to maintain and develop their primary industries even further due to the excess wealth. For instance, European Union agricultural subsidies provide buffers against fluctuating inflation-rates and prices of agricultural produce. This allows developed countries to export their agricultural products at extraordinarily low prices. This makes them extremely competitive against those of poor or underdeveloped countries that maintain free-market policies and low or non-existent tariffs to counter cheap goods. Such price differences also come about due to more efficient production in developed economies, given farm machinery, better information available to farmers, and (often) larger scale.

Some economies exhibit a particular emphasis on the basic food-providing parts of the primary sector (farming and fishing), wishing to guarantee via autarky in food-production that citizens can eat even in extreme circumstances (such as war, blockade, or sanctions). The agricultural revolution may not have preceded the industrial revolution entirely by chance.

Secondary sector of the economy

The **secondary sector of the economy** includes industries that produce a finished, usable product or are involved in construction.

This sector generally takes the output of the primary sector and manufactures finished goods or where they are suitable for use by other businesses, for export, or sale to domestic consumers. This sector is often divided into light industry and heavy industry. Many of these industries consume large quantities of energy and require factories and machinery to convert raw materials into goods and products. They also produce waste materials and waste heat that may cause environmental problems or cause pollution. The secondary sector supports both the primary and tertiary sector.

Some economists contrast wealth-producing sectors in an economy such as manufacturing with the service sector which tends to be wealth-consuming. Examples of service may include retail, insurance, and government. These economists contend that an economy begins to decline as its wealth-producing sector shrinks. Manufacturing is an important activity to promote economic growth and development. Nations that export manufactured products tend to generate higher marginal GDP growth which supports higher incomes and marginal tax revenue needed to fund the quality of life initiatives such as health care and infrastructure in the economy. The field is an important source for engineering job opportunities. Among developed countries, it is an important source of well-paying jobs for the middle class to facilitate greater social mobility for successive generations on the economy.

Tertiary sector of the economy

The **tertiary sector** or **service sector** is the third of the three economic sectors of the three-sector theory. The others are the secondary sector (approximately the same as manufacturing), and the primary sector (raw materials).

The service sector consists of the production of services instead of end products. Services (also known as "intangible goods") include attention, advice, access, experience, and affective labour. The production of information has long been regarded as a service, but some economists now attribute it to a fourth sector, the quaternary sector.

The tertiary sector of industry involves the provision of services to other businesses as well as final consumers. Services may involve the transport, distribution and sale of goods from producer to a consumer, as may happen in wholesaling and retailing. The goods may be transformed in the process of providing the service, as happens in the restaurant industry. However, the focus is on people interacting with people and serving the customer rather than transforming physical goods.

Difficulty of definition

It is sometimes hard to define whether a given company is part and parcel of the secondary or tertiary sector. And it is not only companies that have been classified as part of that sector in some schemes; government and its services such as police or military, and non-profit organizations such as charities or research associations can also be seen as part of that sector.

In order to classify a business as a service, one can use classification systems such as the United Nations' International Standard Industrial Classification standard, the United States' Standard Industrial Classification (SIC) code system and its new replacement, the North American Industrial Classification System (NAICS), the Statistical Classification of Economic Activities in the European Community (NACE) in the EU and similar systems elsewhere. These governmental classification systems have a first-level hierarchy that reflects whether the economic goods are tangible or intangible.

For purposes of finance and market research, market-based classification systems such as the Global Industry Classification Standard and the Industry Classification Benchmark are used to classify businesses that participate in the service sector. Unlike governmental classification systems, the first level of market-based classification systems divides the economy into functionally related markets or industries. The second or third level of these hierarchies then reflects whether goods or services are produced.

Theory of progression

For the last 100 years, there has been a substantial shift from the primary and secondary sectors to the tertiary sector in industrialized countries. This shift is called **tertiarisation**. The tertiary sector is now the largest sector of the economy in the Western world, and is also the fastest-growing sector. In examining the growth of the service sector in the early Nineties, the globalist Kenichi Ohmae noted that:

"In the United States 70 percent of the workforce works in the service sector; in Japan, 60 percent, and in Taiwan, 50 percent. These are not necessarily busboys and live-in maids. Many of them are in the professional category. They are earning as much as manufacturing workers, and often more."

Economies tend to follow a developmental progression that takes them from a heavy reliance on agriculture and mining, toward the development of manufacturing (e.g. automobiles, textiles, shipbuilding, steel) and finally toward a more service-based structure. The first economy to follow this path in the modern world was the United Kingdom. The speed at which other economies have made the transition to service-based (or "post-industrial") economies has increased over time.

Historically, manufacturing tended to be more open to international trade and competition than services. However, with dramatic cost reduction and speed and reliability improvements in the transportation of people and the communication of information, the service sector now includes some of the most intensive international competition, despite residual protectionism.

Issues for service providers

Service providers face obstacles selling services that goods-sellers rarely face. Services are intangible, making it difficult for potential customers to understand what they will receive and what value it will hold for them. Indeed, some, such as consultants and providers of investment services, offer no guarantees of the value for price paid.

Since the quality of most services depends largely on the quality of the individuals providing the services, "people costs" are usually a high fraction of service costs. Whereas a manufacturer may use technology, simplification, and other techniques to lower the cost of goods sold, the service provider often faces an unrelenting pattern of increasing costs.

Product differentiation is often difficult. For example, how does one choose one investment adviser over another, since they are often seen to provide identical services? Charging a premium for services is usually an option only for the most established firms, who charge extra based upon brand recognition.

Examples of tertiary industries

Examples of tertiary industries may include:

- o Telecommunication
- o Hospitality industry/tourism
- o Mass media
- o Healthcare/hospitals
- o Public health
- o Pharmacy
- o Information technology
- o Waste disposal
- o Consulting
- o Retail sales
 - o Fast-moving consumer goods (FMCG)
- o Franchising
- o Real estate
- o Education
- o Financial services
 - o Banking
 - o Insurance
 - o Investment management
- o Professional services

- o Accounting
- o Legal services
- o Management consulting
- o Transportation

Quaternary sector of the economy

The **quaternary sector** of any city is a way to describe a knowledge-based part of the economy, which typically includes knowledge-oriented economic sectors such as information technology, media, research and development; information-based services such as information-generation and information-sharing; and knowledge-based services such as consultation, education, financial planning, blogging, and designing.

The quaternary sector is based on pure knowledge and skill of a person. This skill can help people get into more advanced jobs than just any normal jobs like mopping the floors. It consists of intellectual industries providing information services, such as computing and ICT (information and communication technologies), consultancy (offering advice to businesses) and R&D (research, particularly in scientific fields). According to some definitions, the quaternary sector includes other *pure* services, such as the entertainment industry, and the term has been used to describe media, culture, and government.

"Quaternary sector" is a further delineation of the three-sector hypothesis of industry in the sense that the *quaternary sector* refers to a part of the third or tertiary sector along with the quinary economic sector. Intellectual services are sometimes regarded as distinct enough to warrant a separate sector and not be considered merely as a part of the tertiary sector. This sector evolves in well-developed countries where the primary and secondary sectors are a minority of the economy, and requires a highly educated workforce.

Quinary sector of the economy

Quinary activities are services that focus on the creation, re-arrangement and interpretation of new and existing ideas; data interpretation and the use and evaluation of new technologies. Often referred to as 'gold collar' professions, they represent another subdivision of the tertiary sector representing special and highly paid skills of senior business executives, government officials, research scientists, financial and legal consultants, etc. Their importance in the structure of advanced economies far outweighs their numbers. The highest level of decision makers or policy makers perform quinary activities (Economic sector).

UNIT-14

CONCEPT OF HAZARDS AND DISASTERS; PHYSICAL HAZARDS: TROPICAL CYCLONE, FLOOD, LAND SLIDE WITH REFERENCE TO WEST BENGAL

A **hazard** is an agent which has the potential to cause harm to a vulnerable target. The terms "hazard" and "risk" are often used interchangeably. However, in terms of risk assessment, they are two very distinct terms. A hazard is any agent that can cause harm or damage to humans, property, or the environment. Risk is defined as the probability that exposure to a hazard will lead to a negative consequence, or more simply, a hazard poses no risk if there is no exposure to that hazard.

Hazards can be dormant or potential, with only a theoretical probability of harm. An event that is caused by interaction with a hazard is called an incident. The likely severity of the undesirable consequences of an incident associated with a hazard, combined with the probability of this occurring, constitute the associated risk. If there is no possibility of a hazard contributing towards an incident, there is no risk.

Hazards can be classified as different types in several ways. One of these ways is by specifying the origin of the hazard. One key concept in identifying a hazard is the presence of stored energy that, when released, can cause damage. Stored energy can occur in many forms: chemical, mechanical, thermal, radioactive, electrical, etc. Another class of hazard does not involve release of stored energy, rather it involves the presence of hazardous situations. Examples include confined or limited egress spaces, oxygen-depleted atmospheres, awkward positions, repetitive motions, low-hanging or protruding objects, etc. Hazards may also be classified as natural, anthropogenic, or technological. They may also be classified as health or safety hazards, by the populations that may be affected, and the severity of the associated risk. In most cases a hazard may affect a range of targets, and have little or no effect on others.

Identification of hazards assumes that the potential targets are defined, and is the first step in performing a risk assessment.

Definition

Zaplatynskiy V. (2013) defines "Hazard" - a subjective concept that refers to the possibility of the circumstances under which the matter, field, information, energy, or both of them may influence the complex system, it would lead to consequences that are, or valued stakeholders (at the level of thinking, feeling or instinct) at a certain stage of development of the perceiver as negative.

Kates (1978) defines environmental hazard as "the threat potential posed to man or nature by events originating in, or transmitted by, the natural or built environment". This definition includes a broader range of hazards ranging from long term environmental deterioration such as acidification of soils and build-up of atmospheric carbon dioxide to communal and involuntary social hazards such as crime and terrorism to voluntary and personal hazards such as drug abuse and mountain climbing. Environmental hazards usually have defined or common characteristics including their tendency to be rapid onset events meaning they occur with a short warning time, they have a clear source of origin which is easily identified, impact will be swift and losses suffered quickly during or shortly after on-set of the event, risk of exposure is usually involuntary due to location or proximity of people to the hazard and the "disaster occurs with an intensity and scale that justifies an emergency response".

Hazards may be grouped according to their characteristics. These factors are related to geophysical events which are not process specific:

1. Areal extent of damage zone
2. Intensity of impact at a point
3. Duration of impact at a point

4. Rate of onset of the event

5. Predictability of the event

Natural hazards may be defined as "extreme events that originate in the biosphere, hydrosphere, lithosphere or atmosphere" or "a potential threat to humans and their welfare" which include earthquake, landslide, hurricane and tsunamis. Technological and man made hazards include explosions, release of toxic materials, episodes of severe contamination, structural collapses, and transportation, construction and manufacturing accidents etc. A distinction can also be made between rapid onset natural hazards, technological hazards and social hazards which are described as being of sudden occurrence and relatively short duration, and the consequences of longer term environmental degradation such as desertification and drought, .

In defining hazard Keith Smith argues that what may be defined as hazard is only a hazard if there is the presence of humans to make it a hazard and that it is otherwise merely an event of interest. In this sense the environmental conditions we may consider hostile or hazardous can be seen as neutral in that it is our perception, human location and actions which identify resources and hazards within the range of natural events. In this regard human sensitivity to environmental hazards is a combination of both physical exposure (natural and/or technological events at a location related to their statistical variability) and human vulnerability (in regard to social and economic tolerance of the same location).

Smith states that natural hazards are best seen in an ecological framework in order to distinguish between natural events as natural hazards. He says "natural hazards, therefore, result from the conflict of geophysical processes with people and they lie at the interface what has been called the natural events system and the human interface system." He says that "this interpretation of natural hazards gives humans a central role. Firstly through location, because it is only when people and their possessions get in the way of natural processes that hazard exists."

A natural hazard can be considered as a geophysical event which when it occurs in extremes and a human factor is involved that may present a risk. In this context we can see that there may be an acceptable variation of magnitude which can vary from the estimated normal or average range with upper and lower limits or thresholds. In these extremes the natural occurrence may become an event that presents risk to the environment or people. Smith says "most social and economic activities are geared to some expectation of the 'average' conditions. As long as the variation of the environmental element remains fairly close to this expected performance, insignificant damage occurs and the element will be perceived as beneficial. However when the variability exceeds some threshold beyond the normal band of tolerance, the same variable starts to impose a stress on society and become a hazard." Thus above average wind speeds resulting in a tropical depression or hurricane according to intensity measures on the Saffir–Simpson scale will provide an extreme natural event which may be considered a hazard.

Classification

Hazards can be classified as different types in several ways. One of these ways is by specifying the origin of the hazard. One key concept in identifying a hazard is the presence of stored energy that, when released, can cause damage. Stored energy can occur in many forms: chemical, mechanical, thermal, radioactive, electrical, etc. Another class of hazard does not involve release of stored energy, rather it involves the presence of hazardous situations. Examples include confined or limited egress spaces, oxygen-depleted atmospheres, awkward positions, repetitive motions, low-hanging or protruding objects, etc.

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In most cases a hazard may affect a range of targets, and have little or no effect on others. Identification of hazards assumes that the potential targets are defined.

BASED ON ENERGY SOURCE

Biological hazard

Biological hazards, also known as biohazards, originate in biological processes of living organisms, and refer to agents that pose a threat to the health of living organisms, the security of property, or the health of the environment.

The term and its associated symbol may be used as a warning, so that those potentially exposed to the substances will know to take precautions. The biohazard symbol was developed in 1966 by Charles Baldwin, an environmental-health engineer working for the Dow Chemical Company on the containment products, and is used in the labeling of biological materials that carry a significant health risk, such as viral samples and used hypodermic needles.

Biological hazards include viruses, parasites, bacteria, food, fungi, and foreign toxins.

Many specific biological hazards have been identified. For example, the hazards of naturally-occurring bacteria such as *Escherichia coli* and *Salmonella*, are well known as disease-causing pathogens and a variety of measures have been taken to limit human exposure to these microorganisms through food safety, good personal hygiene and education. However, the potential for new biological hazards exists through the discovery of new microorganisms and through the development of new genetically modified (GM) organisms. Use of new GM organisms is regulated by various governmental agencies. The US Environmental Protection Agency (EPA) controls GM plants that produce or resist pesticides (i.e. Bt corn and Roundup ready crops). The US Food and Drug Administration (FDA) regulates GM plants that will be used as food or for medicinal purposes.

Biological hazards can include medical waste or samples of a microorganism, virus or toxin (from a biological source) that can affect health.

Many biological hazards are associated with food, including certain viruses, parasites, fungi, bacteria, and plant and seafood toxins. Pathogenic *Campylobacter* and *Salmonella* are common foodborne biological hazards. The hazards from these bacteria can be avoided through risk mitigation steps such as proper handling, storing, and cooking of food. Disease in humans can come from biological hazards in the form of infection by bacteria, antigens, viruses, or parasites.

Chemical hazard

A chemical can be considered a hazard if by virtue of its intrinsic properties it can cause harm or danger to humans, property, or the environment.

Health hazards associated with chemicals are dependent on the dose or amount of the chemical. For example, iodine in the form of potassium iodate is used to produce iodised salt. When applied at a rate of 20 mg of potassium iodate per 1000 mg of table salt, the chemical is beneficial in preventing goiter, while iodine intakes of 1200–9500 mg in one dose have been known to cause death. Some chemicals

have a cumulative biological effect, while others are metabolically eliminated over time. Other chemical hazards may depend on concentration or total quantity for their effects.

A variety of chemical hazards (e.g. DDT, atrazine, etc.) have been identified. However, every year companies produce more new chemicals to fill new needs or to take the place of older, less effective chemicals. Laws, such as the Federal Food, Drug, and Cosmetic Act and the Toxic Substances Control Act in the US, require protection of human health and the environment for any new chemical introduced. In the US, the EPA regulates new chemicals that may have environmental impacts (i.e. pesticides or chemicals released during a manufacturing process), while the FDA regulates new chemicals used in foods or as drugs. The potential hazards of these chemicals can be identified by performing a variety of tests prior to the authorization of usage. The number of tests required and the extent to which the chemicals are tested varies, depending on the desired usage of the chemical. Chemicals designed as new drugs must undergo more rigorous tests than those used as pesticides.

Some harmful chemicals occur naturally in certain geological formations, such as radon gas or arsenic. Other chemicals include products with commercial uses, such as agricultural and industrial chemicals, as well as products developed for home use. Pesticides, which are normally used to control unwanted insects and plants, may cause a variety of negative effects on non-target organisms. DDT can build up, or bioaccumulate, in birds, resulting in thinner-than-normal egg shells which can break in the nest. The organochlorine pesticide dieldrin has been linked to Parkinson's disease. Corrosive chemicals like sulfuric acid, which is found in car batteries and research laboratories, can cause severe skin burns. Many other chemicals used in industrial and laboratory settings can cause respiratory, digestive, or nervous system problems if they are inhaled, ingested, or absorbed through the skin. The negative effects of other chemicals, such as alcohol and nicotine, have been well documented.

Ergonomic hazard

Ergonomic hazards are physical conditions that may pose risk of injury to the musculoskeletal system, such as the muscles or ligaments of the lower back, tendons or nerves of the hands/wrists, or bones surrounding the knees. Ergonomic hazards include things such as awkward or extreme postures, whole-body or hand/arm vibration, poorly designed tools, equipment, or workstations, repetitive motion, and poor lighting. Ergonomic hazards occur in both occupational and non-occupational settings such as in workshops, building sites, offices, home, school, or public spaces and facilities.

Mechanical hazard

A mechanical hazard is any hazard involving a machine or industrial process. Motor vehicles, aircraft, and air bags pose mechanical hazards. Compressed gases or liquids can also be considered a mechanical hazard.

Hazard identification of new machines and/or industrial processes occurs at various stages in the design of the new machine or process. These hazard identification studies focus mainly on deviations from the intended use or design and the harm that may occur as a result of these deviations. These studies are regulated by various agencies such as the Occupational Safety and Health Administration and the National Highway Traffic Safety Administration.

Physical hazard

A physical hazard is a naturally occurring process that has the potential to create loss or damage. Physical hazards include earthquakes, floods, fires, and tornadoes. Physical hazards often have both human and natural elements. Flood problems can be affected by the natural elements of climate fluctuations and storm frequency, and by land drainage and building in a flood plain, human

elements. Another physical hazard, X-rays, naturally occur from solar radiation, but have also been utilized by humans for medical purposes; however, overexposure can lead to cancer, skin burns, and tissue damage.

Psychosocial hazard

Psychological or psychosocial hazards are hazards that affect the psychological well-being of people, including their ability to participate in a work environment among other people. Psychosocial hazards are related to the way work is designed, organized and managed, as well as the economic and social contexts of work and are associated with psychiatric, psychological and/or physical injury or illness. Linked to psychosocial risks are issues such as occupational stress and workplace violence which are recognized internationally as major challenges to occupational health and safety. Based on origin

Natural hazards

Natural hazards such as earthquakes, floods, volcanoes and tsunamis have threatened people, society, the natural environment, and the built environment, particularly more vulnerable people, throughout history, and in some cases, on a day-to-day basis. According to the Red Cross, each year 130,000 people are killed, 90,000 are injured and 140 million are affected by unique events known as natural disasters.

Recent policy-oriented work into hazard management began with the work of Gilbert White, the first person to study engineering schemes as a means of mitigating flooding in the US. From 1935 to 1967 White and his colleagues led the research into flood defences, and further collaboration on investigation was undertaken at the University of Chicago.

In December 1989, after several years of preparation, the United Nations General Assembly adopted resolution 44/236 proclaiming the 1990s as the International Decade for Natural Disaster Reduction. The objective of that decade was stated in the annex of Resolution 44/236 as follows:

"...to reduce through concerted international action, especially in developing countries, the loss of life, property damage, and social and economic disruption caused by natural disasters, such as earthquakes, wind-storms, tsunamis, floods, landslides, volcanic eruptions, wildfire, grasshopper and locust infestations, drought and desertification and other calamities of natural origin."

Methods to reduce risk from natural hazards include construction of high-risk facilities away from areas with high risk, engineering redundancy, emergency reserve funds, purchasing relevant insurance, and the development of operational recovery plans.

Anthropogenic hazards

Hazards due to human behaviour and activity.

The social, natural and built environment are not only at risk from geophysical hazards, but also from technological hazards including industrial explosions, release of chemical hazards and major accident hazards (MAHs).

Technological hazards

Hazards due to technology, and therefore a sub-class of anthropogenic hazards.

Sociological hazards

Hazards due to sociological causes, also a sub-class of anthropogenic hazards

Sociological hazards include crime, terrorist threats and war.

Environmental hazards

Any single or combination of toxic chemical, biological, or physical agents in the environment, resulting from human activities or natural processes, that may impact the health of exposed subjects, including pollutants such as heavy metals, pesticides, biological contaminants, toxic waste, industrial and home chemicals.

BASED ON EFFECTS

Health hazards

Hazards affecting the health of exposed persons, usually having an acute or chronic illness as the consequence. Fatality would not normally be an immediate consequence. Health hazards may cause measurable changes in the body which are generally indicated by the development of signs and symptoms in the exposed persons, or non-measurable, subjective symptoms.

Safety hazards

Hazards affecting the safety of individuals, usually having an injury or immediate fatality as the consequence of an incident.

Economic hazards

Hazards affecting property, wealth and the economy.

Environmental hazards

Hazards affecting the environment, particularly the natural environment and ecosystems.

DISASTER

Disaster can be defined as a serious disruption, occurring over a relatively short time, of the functioning of a community or a society involving widespread human, material, economic, societal or environmental loss and impacts, which exceeds the ability of the affected community or society to cope using its own resources. Disaster can manifest in various forms, threatening those people or environments specifically vulnerable. Such impacts include loss of property, death, injury, trauma or post-traumatic stress disorder.

Disaster can take various forms, including hurricane, volcano, tsunami, earthquake, drought, famine, plague, disease, rail crash, car crash, tornado, deforestation, flooding, toxic release, and spills (oil, chemicals). These can affect people and the environment on the local regional level, national level or international level (Wisner et al., unknown) where the international community becomes involved with aid donation, governments give money to support affected countries' economies with disaster response and post-disaster reconstruction.

A disaster hazard is an extreme geophysical event that is capable of causing a disaster. 'Extreme' in this case means a substantial variation in either the positive or the negative direction from the normal trend; flood disasters can result from exceptionally high precipitation and river discharge, and drought is caused by exceptionally low values. The fundamental determinants of hazard and the risk of such hazards occurring is timing, location, magnitude and frequency. For example, magnitudes of earthquakes are measured on the Richter scale from 1 to 10, whereby each increment of 1 indicates a tenfold increase in severity. The magnitude-frequency rule states that over a significant period of time many small events and a few large ones will occur. Hurricanes and typhoons on the other hand occur between 5 degrees and 25 degrees north and south of the equator, tending to be seasonal phenomena which are thus largely recurrent in time and predictable in location due to the specific climate variables necessary for their formation.

Major disaster, as it is usually assessed on quantitative criteria of death and damage was defined by Sheehan and Hewitt (1969) having to conform to the following criteria:

- At least 100 people dead,
- at least 100 people injured, or
- at least \$1 million damage.

This definition includes indirect losses of life caused after initial onset of the disaster such as secondary effects of, e.g., cholera or dysentery. This definition is still commonly used but has the limitations of number of deaths, injuries and damage (in \$). UNDRO (1984) defined a disaster in a more qualitative fashion as:

an event, concentrated in time and space, in which a community undergoes severe danger and incurs such losses to its members and physical appurtenances that the social structure is disrupted and the fulfillment of all or some of the essential functions of the society is prevented.

As with other definitions of disaster, this definition not only encompasses social aspect of disaster impact and stresses potentially caused but also focuses on losses, implying the need for an emergency response as an aspect of disaster. It does not however set out quantitative thresholds or scales for damage, death or injury respectively.

Status of hazard

- **Dormant**—The situation environment is currently affected. For instance, a hillside may be unstable, with the potential for a landslide, but there is nothing below or on the hillside that could be affected.
- **Armed**—People, property, or environment is in potential harm's way.
- **Active**—A harmful incident involving the hazard has actually occurred. Often this is referred to not as an "active hazard" but as an accident, emergency, incident, or disaster.

RISK

The terms "hazard" and "risk" are often used interchangeably. However, in terms of risk assessment, these are two very distinct terms. A hazard is an agent that can cause harm or damage to humans, property, or the environment. Risk is the probability that exposure to a hazard will lead to a negative consequence, or more simply, a hazard poses no risk if there is no exposure to that hazard.

Risk can be defined as the likelihood or probability of a given hazard of a given level causing a particular level of loss or damage. The elements of risk are populations, communities, the built environment, the natural environment, economic activities and services which are under threat of disaster in a given area. The total risk according to UNDRO 1982 is the "sum of predictable deaths, injuries, destruction, damage, disruption, and costs of repair and mitigation caused by a disaster of a particular level in a given area or areas.

David Alexander distinguishes between risk and vulnerability saying that "vulnerability refers to the potential for casualty, destruction, damage, disruption or other form of loss in a particular element: risk combines this with the probable level of loss to be expected from a predictable magnitude of hazard (which can be considered as the manifestation of the agent that produces the loss)." As hazards have varying degrees of severity, the more intense or severe the hazard, the greater vulnerability there will be as potential for damage and destruction is increased with respect to severity of hazard. Ben Wisner argues that risk or disaster is "a compound function of the natural hazard and the number of people, characterised by their varying degrees of vulnerability to that specific hazard, who occupy the space and time of exposure to the hazard event." (Wisner, et al., 1994).

Another definition of risk is "the probable frequency and probable magnitude of future losses". This definition also focuses on the probability of future loss whereby degree of vulnerability to hazard represents the level of risk on a particular population or environment. The threats posed by a hazard are:

Hazards to people – death, injury, disease and stress

Hazards to goods – property damage and economic loss

Hazards to environment –loss of flora and fauna, pollution and loss of amenity

Marking of hazards

Hazard symbols or warning symbols are easily recognisable symbols designed to warn about hazardous materials, locations, or objects. The use of hazard symbols is often regulated by law and directed by standards organisations. Hazard symbols may appear with different colors, backgrounds, borders and supplemental information in order to specify the type of hazard and the level of threat (for example, toxicity classes). Warning symbols are used in many places in lieu of or addition to written warnings as they are quickly recognized (faster than reading a written warning) and more universally understood, as the same symbol can be recognized as having the same meaning to speakers of different languages.

Tropical cyclone

A **tropical cyclone** is a rapidly rotating storm system characterized by a low-pressure centre, a closed low-level atmospheric circulation, strong winds, and a spiral arrangement of thunderstorms that produce heavy rain. Depending on its location and strength, a tropical cyclone is referred to by different names, including hurricane, typhoon tropical storm, cyclonic storm, tropical depression, and simply cyclone. A hurricane is a tropical cyclone that occurs in the Atlantic Ocean and north eastern Pacific Ocean, and a typhoon occurs in the north western Pacific Ocean; while in the south Pacific or Indian Ocean, comparable storms are referred to simply as "tropical cyclones" or "severe cyclonic storms".

"Tropical" refers to the geographical origin of these systems, which form almost exclusively over tropical seas. "Cyclone" refers to their winds moving in a circle, whirling round their central clear eye, with their winds blowing counter clockwise in the Northern Hemisphere and blowing

clockwise in the Southern Hemisphere. The opposite direction of circulation is due to the Coriolis effect. Tropical cyclones typically form over large bodies of relatively warm water. They derive their energy through the evaporation of water from the ocean surface, which ultimately recondenses into clouds and rain when moist air rises and cools to saturation. This energy source differs from that of mid-latitude cyclonic storms, such as nor'easters and European windstorms, which are fueled primarily by horizontal temperature contrasts. Tropical cyclones are typically between 100 and 2,000 km (62 and 1,243 mi) in diameter.

The strong rotating winds of a tropical cyclone are a result of the conservation of angular momentum imparted by the Earth's rotations air flows inwards toward the axis of rotation. As a result, they rarely form within 5° of the equator. Tropical cyclones are almost unknown in the South Atlantic due to a consistently strong wind shear and a weak Intertropical Convergence Zone. Also, the African easterly jet and areas of atmospheric instability which gives rise to cyclones in the Atlantic Ocean and Caribbean Sea, along with the Asian monsoon and Western Pacific Warm Pool, are features of the Northern Hemisphere and Australia.

Coastal regions are particularly vulnerable to the impact of a tropical cyclone, compared to inland regions. The primary energy source for these storms is warm ocean waters, therefore these forms are typically strongest when over or near water, and weaken quite rapidly over land. Coastal damage may be caused by strong winds and rain, high waves (due to winds), storm surges (due to severe pressure changes), and the potential of spawning tornadoes. Tropical cyclones also draw in air from a large area—which can be a vast area for the most severe cyclones—and concentrate the precipitation of the water content in that air (made up from atmospheric moisture and moisture evaporated from water) into a much smaller area. This continual replacement of moisture-bearing air by new moisture-bearing air after its moisture has fallen as rain, may cause extremely heavy rain and river flooding up to 40 kilometres (25 mi) from the coastline, far beyond the amount of water that the local atmosphere holds at any one time.

Though their effects on human populations are often devastating, tropical cyclones can relieve drought conditions. They also carry heat energy away from the tropics and transport it toward temperate latitudes, which may play an important role in modulating regional and global climate.

Severe Cyclonic Storm Aila was the worst natural disaster to affect Bangladesh since Cyclone Sidr in November 2007. The second tropical cyclone of the 2009 North Indian Ocean cyclone season, Aila formed over the Bay of Bengal on May 23. A relatively strong tropical cyclone, it caused extensive damage in India and Bangladesh.

The storm was responsible for at least 339 deaths across Bangladesh and India; more than 1 million people were left homeless. Health officials in Bangladesh confirmed a deadly outbreak of diarrhoea on 29 May, with more than 7,000 people being infected and four dying. In Bangladesh, an estimated 20 million people were at risk of post-disaster diseases due to Aila (Wikipedia).

Flood

A **flood** is an overflow of water that submerges land that is usually dry. The European Union (EU) Floods Directive defines a flood as a covering by water of land not normally covered by water. In the sense of "flowing water", the word may also be applied to the inflow of the tide. Floods

are an area of study of the discipline hydrology and are of significant concern in agriculture, civil engineering and public health.

Flooding may occur as an overflow of water from water bodies, such as a river, lake, or ocean, in which the water overtops or breaks levees, resulting in some of that water escaping its usual boundaries, or it may occur due to an accumulation of rainwater on saturated ground in an areal flood. While the size of a lake or other body of water will vary with seasonal changes in precipitation and snow melt, these changes in size are unlikely to be considered significant unless they flood property or drown domestic animals.

Floods can also occur in rivers when the flow rate exceeds the capacity of the river channel, particularly at bends or meanders in the waterway. Floods often cause damage to homes and businesses if they are in the natural flood plains of rivers. While riverine flood damage can be eliminated by moving away from rivers and other bodies of water, people have traditionally lived and worked by rivers because the land is usually flat and fertile and because rivers provide easy travel and access to commerce and industry.

Some floods develop slowly, while others such as flash floods, can develop in just a few minutes and without visible signs of rain. Additionally, floods can be local, impacting a neighbourhood or community, or very large, affecting entire river basins.

The flood problems of the state are of different nature at different regions. The rivers Teesta, Torsa, Jaldhaka, Raidak-I, Raidak-II etc. flowing through the districts of Jalpaiguri and Cooch Behar originate in the neighbouring country of Bhutan and the state of Sikkim and flows down to Bangladesh, another neighbouring country to meet the Brahmaputra at different locations.

The rivers of the districts of Uttar Dinajpur and Dakshin Dinajpur originating at Bangladesh passes through these districts and then joins the Ganga-Padma at downstream of Farakka in Bangladesh. Both the places of origin and also the outfall of most of these rivers are in Bangladesh. The district of Malda through which the river Ganga flows receives its flood water from about 11 (eleven) States and is battered by the run-off flow generated from these vast areas. Ultimately the river flows down the Farakka Barrage to Bangladesh. Another portion of the Malda district receives floodwaters of the Mahananda, which again originates in the hills of the neighbouring country of Nepal and has some catchment area in the neighbouring state of Bihar and then passes through the district to join the Ganga-Padma at downstream of Farakka Barrage in Bangladesh. Major contributing factors to flood in North Bengal regions are the run-off because of heavy local rainfall, discharge of upper basin areas and also outfall condition in the neighbouring countries. The Mahananda and most of the rivers of Uttar and Dakshin Dinajpur districts get stagnated when the Ganga upstream and downstream of Farakka Barrage rules high thereby not allowing drainage of flood discharge during that period (Flood).

Land slide

The term landslide or, less frequently, landslip, refers to several forms of mass wasting that include a wide range of ground movements, such as rock falls, deep-seated slope failures, mudflows and debris

flows. Landslides can occur underwater, in which case they are called submarine landslides, and in coastal and onshore environments. Although the action of gravity is the primary driving force for a landslide to occur, there are other contributing factors affecting slope stability. Typically, pre-conditional factors build up specific surface or sub-surface conditions that make a slope prone to failure, whereas the actual landslide often requires a trigger before being released.

Debris flow

Slope material that becomes saturated with water may develop into a debris flow or mud flow. The resulting slurry of rock and mud may pick up trees, houses and cars, thus blocking bridges and tributaries causing flooding along its path.

Debris flow is often mistaken for flash flood, but they are entirely different processes.

Muddy-debris flows in alpine areas cause severe damage to structures and infrastructure and often claim human lives. Muddy-debris flows can start as a result of slope-related factors and shallow landslides can dam stream beds, resulting in temporary water blockage. As the impoundments fail, a "domino effect" may be created, with a remarkable growth in the volume of the flowing mass, which takes up the debris in the stream channel. The solid-liquid mixture can reach densities of up to 2,000 kg/m (120 lb/cu ft) and velocities of up to 14 m/s (46 ft/s). These processes normally cause the first severe road interruptions, due not only to deposits accumulated on the road (from several cubic metres to hundreds of cubic metres), but in some cases to the complete removal of bridges or roadways or railways crossing the stream channel. Damage usually derives from a common underestimation of mud-debris flows: in the alpine valleys, for example, bridges are frequently destroyed by the impact force of the flow because their span is usually calculated only for a water discharge. For a small basin in the Italian Alps (area 1.76 km (0.68 sq mi)) affected by a debris flow, estimated a peak discharge of 750 m/s (26,000 cu ft/s) for a section located in the middle stretch of the main channel. At the same cross section, the maximum foreseeable water discharge (by HEC-1), was 19 m/s (670 cu ft/s), a value about 40 times lower than that calculated for the debris flow that occurred.

Earthflow

An Earthflow is the downslope movement of mostly fine-grained material. Earthflows can move at speeds within a very wide range, from as low as 1 mm/yr (0.039 in/yr) to 20 km/h (12.4 mph). Though these are a lot like mudflows, overall they are more slow moving and are covered with solid material carried along by flow from within. They are different from fluid flows which are more rapid. Clay, fine sand and silt, and fine-grained, pyroclastic material are all susceptible to earthflows. The velocity of the earthflow is all dependent on how much water content is in the flow itself: the higher the water content in the flow, the higher the velocity will be.

These flows usually begin when the pore pressures in a fine-grained mass increase until enough of the weight of the material is supported by pore water to significantly decrease the internal shearing strength of the material. This thereby creates a bulging lobe which advances with a slow, rolling motion. As these lobes spread out, drainage of the mass increases and the margins dry out, thereby lowering the overall velocity of the flow. This process causes the flow to thicken. The bulbous variety of earthflows are not that spectacular, but they are much more common than their rapid counterparts. They develop a sag at their heads and are usually derived from the slumping at the source.

Earthflows occur much more during periods of high precipitation, which saturates the ground and adds water to the slope content. Fissures develop during the movement of clay-like material which creates the intrusion of water into the earthflows. Water then increases the pore-water pressure and reduces the shearing strength of the material.

Debris slide

A debris slide is a type of slide characterized by the chaotic movement of rocks, soil, and debris mixed with water and/or ice. They are usually triggered by the saturation of thickly vegetated slopes which results in an incoherent mixture of broken timber, smaller vegetation and other debris. Debris avalanches differ from debris slides because their movement is much more rapid. This is usually a result of lower cohesion or higher water content and commonly steeper slopes.

Steep coastal cliffs can be caused by catastrophic debris avalanches. These have been common on the submerged flanks of ocean island volcanos such as the Hawaiian Islands and the Cape Verde Islands. Another slip of this type was Storegga landslide.

Debris slides generally start with big rocks that start at the top of the slide and begin to break apart as they slide towards the bottom. This is much slower than a debris avalanche. Debris avalanches are very fast and the entire mass seems to liquefy as it slides down the slope. This is caused by a combination of saturated material, and steep slopes. As the debris moves down the slope it generally follows stream channels leaving a v-shaped scar as it moves down the hill. This differs from the more U-shaped scar of a slump. Debris avalanches can also travel well past the foot of the slope due to their tremendous speed.

Rock avalanche

A rock avalanche is a type of large and fast-moving landslide. It is rarer than other types of landslides and therefore poorly understood. It exhibits typically a long run-out, flowing very far over a low angle, flat, or even slightly uphill terrain. The mechanisms favouring the long run out can be different, but they typically result in the weakening of the sliding mass as the speed increases.

Shallow Landslide

Landslide in which the sliding surface is located within the soil mantle or weathered bedrock (typically to a depth from few decimeters to some meters) is called a shallow landslide. They usually include debris slides, debris flow, and failures of road cut-slopes. Landslides occurring as single large blocks of rock moving slowly down slope are sometimes called block glides.

Shallow landslides can often happen in areas that have slopes with high permeable soils on top of low permeable bottom soils. The low permeable, bottom soils trap the water in the shallower, high permeable soils creating high water pressure in the top soils. As the top soils are filled with water and become heavy, slopes can become very unstable and slide over the low permeable bottom soils. Say there is a slope with silt and sand as its top soil and bedrock as its bottom soil. During an intense rainstorm, the bedrock will keep the rain trapped in the top soils of silt and sand. As the topsoil becomes saturated and heavy, it can start to slide over the bedrock and become a shallow landslide. R. H. Campbell did a study on shallow landslides on Santa Cruz Island, California. He notes that if permeability decreases with depth, a perched water table may develop in soils at intense precipitation. When pore water pressures are sufficient to reduce effective normal stress to a critical level, failure occurs.

Deep-seated landslide

Deep-seated landslides usually involve deep regolith, weathered rock, and/or bedrock and include large slope failure associated with translational, rotational, or complex movement. This type of landslide potentially occurs in a tectonic active region like Zagros Mountain in Iran. These typically move slowly, only several meters per year, but occasionally move faster. They tend to be larger than shallow landslides and form along a plane of weakness such as a fault or bedding plane. They can be visually identified by concave scarps at the top and steep areas at the toe (Hazard).

UNIT-15

SOCIAL HAZARDS: POVERTY AND CRIME

Poverty is the scarcity or the lack of a certain (variant) amount of material possessions or money. Poverty is a multifaceted concept, which may include social, economic, and political elements. Absolute poverty, extreme poverty, or *destitution* refers to the complete lack of the means necessary to meet basic personal needs such as food, clothing and shelter.

The threshold at which *absolute poverty* is defined is considered to be about the same, independent of the person's permanent location or era. On the other hand, *relative poverty* occurs when a person who lives in a given country does not enjoy a certain minimum level of "living standards" as compared to the rest of the population of that country. Therefore, the threshold at which *relative poverty* is defined varies from one country to another, or from one society to another.

Providing basic needs can be restricted by constraints on government's ability to deliver services, such as corruption, tax avoidance, debt and loan conditionalities and by the brain drain of health care and educational professionals. Strategies of increasing income to make basic needs more affordable typically include welfare, economic freedoms and providing financial services.

Poverty reduction is still a major issue (or a target) for many international organizations such as the United Nations, the World Bank, United States Agency for International Development, Oxfam, CARE, World Vision International, the Bill and Melinda Gates Foundation, and the Red Cross among a plethora of others.

In 2012 it was estimated that, using a poverty line of \$1.25 a day, 1.2 billion people lived in poverty. Given the current economic model, built on GDP, it would take 100 years to bring the world's poorest up to the poverty line of \$1.25 a day. UNICEF estimates half the world's children (or 1.1 billion) live in poverty.

The World Bank forecasted in 2015 that 702.1 million people were living in extreme poverty, down from 1.75 billion in 1990. Extreme poverty is observed in all parts of the world, including developed economies. Of the 2015 population, about 347.1 million people (35.2%) lived in Sub-Saharan Africa and 231.3 million (13.5%) lived in South Asia. According to the World Bank, between 1990 and 2015, the percentage of the world's population living in extreme poverty fell from 37.1% to 9.6%, falling below 10% for the first time. The People's Republic of China accounts for over three quarters of global poverty reduction from 1990 to 2005. Though, as noted, China accounted for nearly half of all extreme poverty in 1990. In public opinion around the world people surveyed tend to incorrectly think extreme poverty hasn't decreased.

During the 2013 to 2015 period The World Bank reported that extreme poverty fell from 11% to 10%, however they also noted that the rate of decline had slowed by nearly half from the 25 year average with parts of sub-saharan Africa returning to early 2000 levels. The World Bank attributed this to increasing violence following the Arab Spring, population increases in Sub-Saharan Africa, and general African inflationary pressures and economic malaise were the primary drivers for this slow down.

There is disagreement among experts as to what would be considered a realistic poverty rate with one considering it "an inaccurately measured and arbitrary cut off". Some contend that a higher poverty

line is needed, such as a minimum of \$7.40 or even \$10 to \$15 a day. They argue that these levels would better reflect the cost of basic needs and normal life expectancy. One estimate places the true scale of poverty much higher than the World Bank, with an estimated 4.3 billion people (59% of the world's population) living with less than \$5 a day and unable to meet basic needs adequately. It has been argued by some academics that the neoliberal policies promoted by global financial institutions such as the IMF and the World Bank are actually exacerbating both inequality and poverty.

Definitions and Etymology

Poverty is the scarcity or the lack of a certain (variant) amount of material possessions or money. The word poverty comes from the old (Norman) French word *poverté* (Modern French: *pauvreté*), from Latin *paupertās* from *pauper* (poor).

There are several definitions of poverty depending on the context of the situation it is placed in, and the views of the person giving the definition.

Income Poverty: a family's income fails to meet a federally established threshold that differs across countries.

United Nations: Fundamentally, poverty is the inability of having choices and opportunities, a violation of human dignity. It means lack of basic capacity to participate effectively in society. It means not having enough to feed and clothe a family, not having a school or clinic to go to, not having the land on which to grow one's food or a job to earn one's living, not having access to credit. It means insecurity, powerlessness and exclusion of individuals, households and communities. It means susceptibility to violence, and it often implies living in marginal or fragile environments, without access to clean water or sanitation.

World Bank: Poverty is pronounced deprivation in well-being, and comprises many dimensions. It includes low incomes and the inability to acquire the basic goods and services necessary for survival with dignity. Poverty also encompasses low levels of health and education, poor access to clean water and sanitation, inadequate physical security, lack of voice, and insufficient capacity and opportunity to better one's life.

Poverty is usually measured as either absolute or relative (the latter being actually an index of income inequality).

In the United Kingdom, the second Cameron ministry came under attack for their redefinition of poverty; poverty is no longer classified by a family's income, but as to whether a family is in work or not. Considering that two-thirds of people who found work were accepting wages that are below the living wage (according to the Joseph Rowntree Foundation) this has been criticised by anti-poverty campaigners as an unrealistic view of poverty in the United Kingdom.

MEASURING POVERTY

Absolute poverty

Absolute poverty refers to a set standard which is consistent over time and between countries. First introduced in 1990, the dollar a day poverty line measured absolute poverty by the standards of the world's poorest countries. The World Bank defined the new international poverty line as \$1.25 a day in 2008 for 2005 (equivalent to \$1.00 a day in 1996 US prices). In October 2015, they reset it to \$1.90 a day.

Absolute poverty, extreme poverty, or abject poverty is "a condition characterized by severe deprivation of basic human needs, including food, safe drinking water, sanitation facilities, health,

shelter, education and information. It depends not only on income but also on access to services." The term 'absolute poverty', when used in this fashion, is usually synonymous with 'extreme poverty': Robert McNamara, the former president of the World Bank, described absolute or extreme poverty as, "a condition so limited by malnutrition, illiteracy, disease, squalid surroundings, high infant mortality, and low life expectancy as to be beneath any reasonable definition of human decency." Australia is one of the world's wealthier nations. In his article published in Australian Policy Online, Robert Tanton notes that, "While this amount is appropriate for third world countries, in Australia, the amount required to meet these basic needs will naturally be much higher because prices of these basic necessities are higher."

However, as the amount of wealth required for survival is not the same in all places and time periods, particularly in highly developed countries where few people would fall below the World Bank Group's poverty lines, countries often develop their own national poverty lines.

An absolute poverty line was calculated in Australia for the Henderson poverty inquiry in 1973. It was \$62.70 a week, which was the disposable income required to support the basic needs of a family of two adults and two dependent children at the time. This poverty line has been updated regularly by the Melbourne Institute according to increases in average incomes; for a single employed person it was \$391.85 per week (including housing costs) in March 2009. In Australia the OECD poverty would equate to a "disposable income of less than \$358 per week for a single adult (higher for larger households to take account of their greater costs). In 2015 Australia implemented the Individual Deprivation Measure which address gender disparities in poverty.

For a few years starting 1990, the World Bank anchored absolute poverty line as \$1 per day. This was revised in 1993, and through 2005, absolute poverty was \$1.08 a day for all countries on a purchasing power parity basis, after adjusting for inflation to the 1993 U.S. dollar. In 2005, after extensive studies of cost of living across the world, The World Bank raised the measure for global poverty line to reflect the observed higher cost of living. In 2015, the World Bank defines extreme poverty as living on less than US\$1.90 (PPP) per day, and *moderate poverty* as less than \$2 or \$5 a day (but note that a person or family with access to subsistence resources, e.g., subsistence farmers, may have a low cash income without a correspondingly low standard of living – they are not living "on" their cash income but using it as a top up). It estimated that "in 2001, 1.1 billion people had consumption levels below \$1 a day and 2.7 billion lived on less than \$2 a day." A 'dollar a day', in nations that do not use the U.S. dollar as currency, does not translate to living a day on the equivalent amount of local currency as determined by the exchange rate. Rather, it is determined by the purchasing power parity rate, which would look at how much local currency is needed to buy the same things that a dollar could buy in the United States. Usually, this would translate to less local currency than the exchange rate in poorer countries as the United States is a relatively more expensive country.

The poverty line threshold of \$1.90 per day, as set by the World Bank, is controversial. Each nation has its own threshold for absolute poverty line; in the United States, for example, the absolute poverty line was US\$15.15 per day in 2010 (US\$22,000 per year for a family of four), while in India it was US\$1.0 per day and in China the absolute poverty line was US\$0.55 per day, each on PPP basis in 2010. These different poverty lines make data comparison between each nation's official reports qualitatively difficult. Some scholars argue that the World Bank method sets the bar too high, others argue it is low. Still others suggest that poverty line misleads as it measures everyone below the poverty line the same, when in reality someone living on \$1.20 per day is in a different state of poverty than someone living on \$0.20 per day. In other words, the depth and intensity of poverty varies across the world and in any regional populations, and \$1.25 per day poverty line and head counts are inadequate measures.

The share of the world's population living in absolute poverty fell from 43% in 1981 to 14% in 2011. The absolute number of people in poverty fell from 1.95 billion in 1981 to 1.01 billion in 2011. The economist Max Roser estimates that the number of people in poverty is therefore roughly

the same as 200 years ago. This is the case since the world population was just little more than 1 billion in 1820 and the majority (84% to 94%) of the world population was living poverty. The proportion of the developing world's population living in extreme economic poverty fell from 28 percent in 1990 to 21 percent in 2001. Most of this improvement has occurred in East and South Asia. In East Asia the World Bank reported that "The poverty headcount rate at the \$2-a-day level is estimated to have fallen to about 27 percent [in 2007], down from 29.5 percent in 2006 and 69 percent in 1990." In Sub-Saharan Africa extreme poverty went up from 41 percent in 1981 to 46 percent in 2001, which combined with growing population increased the number of people living in extreme poverty from 231 million to 318 million.

In the early 1990s some of the transition economies of Central and Eastern Europe and Central Asia experienced a sharp drop in income. The collapse of the Soviet Union resulted in large declines in GDP per capita, of about 30 to 35% between 1990 and the trough year of 1998 (when it was at its minimum). As a result, poverty rates tripled, excess mortality increased, and life expectancy declined. In subsequent years as per capita incomes recovered the poverty rate dropped from 31.4% of the population to 19.6%. The average post-communist country had returned to 1989 levels of per-capita GDP by 2005, although as of 2015 some are still far behind that. According to an article in *Foreign Affairs*, there were generally three paths to economic reform taken post Soviet collapse. Those nations that took a "radical" or "gradual" reform rate have GDP per capita similar to other nations in their stage of economic development at generally 150% of their transition year (1991) GDP. Nations that took a "slow" approach (an approach that limited free market reforms generally) had much slower, and lower economic growth, higher Gini coefficients, and poorer health outcomes. Currently, those nations sit at 125% of their transition year GDP per capita. A 2009 study published in *The Lancet* suggested that radical economic changes and the resulting short term unemployment led to temporary increases in the mortality rate of adult males.

World Bank data shows that the percentage of the population living in households with consumption or income per person below the poverty line has decreased in each region of the world since 1990:

Region	\$1 per day			\$1.25 per day	
	1990	2002	2004	1981	2008
East Asia and Pacific	15.4%	12.3%	9.1%	77.2%	14.3%
Europe and Central Asia	3.6%	1.3%	1.0%	1.9%	0.5%
Latin America and the Caribbean	9.6%	9.1%	8.6%	11.9%	6.5%
Middle East and North Africa	2.1%	1.7%	1.5%	9.6%	2.7%
South Asia	35.0%	33.4%	30.8%	61.1%	36%
Sub-Saharan Africa	46.1%	42.6%	41.1%	51.5%	47.5%
World				52.2%	22.4%

According to Chen and Ravallion, about 1.76 billion people in developing world lived *above* \$1.25 per day and 1.9 billion people lived *below* \$1.25 per day in 1981. The world's population increased over the next 25 years. In 2005, about 4.09 billion people in developing world lived above \$1.25 per day and 1.4 billion people lived below \$1.25 per day (both 1981 and 2005 data are on inflation adjusted basis). Some scholars caution that these trends are subject to various assumptions and not certain. Additionally, they note that the poverty reduction is not uniform across the world; economically prospering countries such as China, India and Brazil have made more progress in absolute poverty reduction than countries in other regions of the world.

The absolute poverty measure trends noted above are supported by human development indicators, which have also been improving. Life expectancy has greatly increased in the developing world since World War II and is starting to close the gap to the developed world. Child mortality has decreased in every developing region of the world. The proportion of the world's population living in countries where per-capita food supplies are less than 2,200 calories (9,200 kilojoules) per day decreased from

56% in the mid-1960s to below 10% by the 1990s. Similar trends can be observed for literacy, access to clean water and electricity and basic consumer items.

Secondary poverty

Secondary poverty refers to those that would be living above the poverty line, but spend their income on unnecessary pleasures, such as alcoholic beverages, thus placing them below it.

In 18th and 19th century Great Britain, the practice of temperance among Methodists, as well as their rejection of gambling, allowed them to eliminate secondary poverty and accumulate capital.

Relative poverty

Relative poverty views poverty as socially defined and dependent on social context, hence relative poverty is a measure of income inequality. Usually, relative poverty is measured as the percentage of the population with income less than some fixed proportion of median income. There are several other different income inequality metrics, for example, the Gini coefficient or the Theil Index.

Relative poverty is the "most useful measure for ascertaining poverty rates in wealthy developed nations". Relative poverty measure is used by the United Nations Development Program (UNDP), the United Nations Children's Fund (UNICEF), the Organisation for Economic Co-operation and Development (OECD) and Canadian poverty researchers. In the European Union, the "relative poverty measure is the most prominent and most-quoted of the EU social inclusion indicators".

"Relative poverty reflects better the cost of social inclusion and equality of opportunity in a specific time and space."

"Once economic development has progressed beyond a certain minimum level, the rub of the poverty problem – from the point of view of both the poor individual and of the societies in which they live – is not so much the effects of poverty in any absolute form but the effects of the contrast, daily perceived, between the lives of the poor and the lives of those around them. For practical purposes, the problem of poverty in the industrialized nations today is a problem of relative poverty (page 9)."

In 1776 Adam Smith in the *Wealth of Nations* argued that poverty is the inability to afford, "not only the commodities which are indispensably necessary for the support of life but whatever the custom of the country renders it indecent for creditable people, even of the lowest order, to be without".

In 1958 J. K. Galbraith argued that "People are poverty stricken when their income, even if adequate for survival, falls markedly behind that of their community."

In 1964 in a joint committee economic President's report in the United States, Republicans endorsed the concept of relative poverty. "No objective definition of poverty exists... The definition varies from place to place and time to time. In America as our standard of living rises, so does our idea of what is substandard."

In 1965 Rose Friedman argued for the use of relative poverty claiming that the definition of poverty changes with general living standards. Those labeled as poor in 1995 would have had "a higher standard of living than many labeled not poor" in 1965.

In 1979, British sociologist, Peter Townsend published his famous definition, "individuals ... can be said to be in poverty when they lack the resources to obtain the types of diet, participate in the activities and have the living conditions and amenities which are customary, or are at least widely encouraged or approved, in the societies to which they belong (page 31)". This definition and measurement of poverty was profoundly linked to the idea that poverty and societal participation are deeply associated.

Peter Townsend transformed the conception of poverty, viewing it not simply as lack of income but as the configuration of the economic conditions that prevent people from being full members of the society (Townsend, 1979; Ferragina et al. 2016). Poverty reduces the ability of people to participate in society, effectively denying them full citizenship (as suggested by T.H. Marshall). Given that there are no universal principles by which to determine the minimum threshold of participation equating to full membership of society, Townsend argued that the appropriate measure would necessarily be relative to any particular cultural context. He suggested that in each society there should be an empirically determinable 'breakpoint' within the income distribution below which participation of individuals collapses, providing a scientific basis for fixing a poverty line and determining the extent of poverty (Ferragina et al. 2016).

Brian Nolan and Christopher T. Whelan of the Economic and Social Research Institute (ESRI) in Ireland explained that "Poverty has to be seen in terms of the standard of living of the society in question."

Relative poverty measures are used as official poverty rates by the European Union, UNICEF, and the OECD. The main poverty line used in the OECD and the European Union is based on "economic distance", a level of income set at 60% of the median household income.

Many wealthy nations have seen an increase in relative poverty rates ever since the Great Recession, in particular among children from impoverished families who often reside in substandard housing and find educational opportunities out of reach.

Other aspects

Economic aspects of poverty focus on material needs, typically including the necessities of daily living, such as food, clothing, shelter, or safe drinking water. Poverty in this sense may be understood as a condition in which a person or community is lacking in the basic needs for a minimum standard of well-being and life, particularly as a result of a persistent lack of income. The increase in poverty runs parallel sides with unemployment, hunger, and higher crime rate.

Analysis of social aspects of poverty links conditions of scarcity to aspects of the distribution of resources and power in a society and recognizes that poverty may be a function of the diminished "capability" of people to live the kinds of lives they value. The social aspects of poverty may include lack of access to information, education, health care, social capital or political power.

Poverty levels are snapshot pictures in time that omits the transitional dynamics between levels. Mobility statistics supply additional information about the fraction who leave the poverty level. For example, one study finds that in a sixteen-year period (1975 to 1991 in the U.S.) only 5% of those in the lower fifth of the income level were still at that level, while 95% transitioned to a higher income category. Poverty levels can remain the same while those who rise out of poverty are replaced by others. The transient poor and chronic poor differ in each society. In a nine-year period ending in 2005 for the U.S., 50% of the poorest quintile transitioned to a higher quintile.

Poverty may also be understood as an aspect of unequal social status and inequitable social relationships, experienced as social exclusion, dependency, and diminished capacity to participate, or to develop meaningful connections with other people in society. Such social exclusion can be minimized through strengthened connections with the mainstream, such as through the provision of relational care to those who are experiencing poverty.

The World Bank's "Voices of the Poor," based on research with over 20,000 poor people in 23 countries, identifies a range of factors which poor people identify as part of poverty. These include:

- Abuse by those in power
- Dis-empowering institutions
- Excluded locations
- Gender relationships
- Lack of security
- Limited capabilities
- Physical limitations
- Precarious livelihoods
- Problems in social relationships
- Weak community organizations
- Discrimination

David Moore, in his book *The World Bank*, argues that some analysis of poverty reflect pejorative, sometimes racial, stereotypes of impoverished people as powerless victims and passive recipients of aid programs.

Ultra-poverty, a term apparently coined by Michael Lipton, connotes being amongst poorest of the poor in low-income countries. Lipton defined ultra-poverty as receiving less than 80 percent of minimum caloric intake whilst spending more than 80% of income on food. Alternatively a 2007 report issued by International Food Policy Research Institute defined ultra-poverty as living on less than 54 cents per day.

Asset poverty is an economic and social condition that is more persistent and prevalent than income poverty. It can be defined as a household's inability to access wealth resources that are enough to provide for basic needs for a period of three months. Basic needs refer to the minimum standards for consumption and acceptable needs. Wealth resources consist of home ownership, other real estate (second home, rented properties, etc.), net value of farm and business assets, stocks, checking and savings accounts, and other savings (money in savings bonds, life insurance policy cash values, etc.). Wealth is measured in three forms: net worth, net worth minus home equity, and liquid assets. Net worth consists of all the aspects mentioned above. Net worth minus home equity is the same except it does not include home ownership in asset calculations. Liquid assets are resources that are readily available such as cash, checking and savings accounts, stocks, and other sources of savings. There are two types of assets: tangible and intangible. Tangible assets most closely resemble liquid assets in that they include stocks, bonds, property, natural resources, and hard assets not in the form of real estate. Intangible assets are simply the access to credit, social capital, cultural capital, political capital, and human capital (Poverty).

CRIME

In ordinary language, a **crime** is an unlawful act punishable by a state or other authority. The term "crime" does not, in modern criminal law, have any simple and universally accepted definition, though statutory definitions have been provided for certain purposes. The most popular view is that crime is a category created by law; in other words, something is a crime if declared as such by the relevant and applicable law. One proposed definition is that a crime or **offence** (or **criminal offence**) is an act harmful not only to some individual but also to a community, society or the state ("a public wrong"). Such acts are forbidden and punishable by law.

The notion that acts such as murder, rape and theft are to be prohibited exists worldwide. What precisely is a criminal offence is defined by criminal law of each country. While many have a catalogue of crimes called the criminal code, in some common law countries no such comprehensive statute exists.

The state (government) has the power to severely restrict one's liberty for committing a crime. In modern societies, there are procedures to which investigations and trials must adhere. If found guilty, an offender may be sentenced to a form of reparation such as a community sentence, or, depending on the nature of their offence, to undergo imprisonment, life imprisonment or, in some jurisdictions, execution.

Usually, to be classified as a crime, the "act of doing something criminal" (*actus reus*) must – with certain exceptions – be accompanied by the "intention to do something criminal" (*mens rea*).

While every crime violates the law, not every violation of the law counts as a crime. Breaches of private law (torts and breaches of contract) are not automatically punished by the state, but can be enforced through civil procedure.

Overview

When informal relationships prove insufficient to establish and maintain a desired social order, a government or a state may impose more formalized or stricter systems of social control. With institutional and legal machinery at their disposal, agents of the State can compel populations to conform to codes and can opt to punish or attempt to reform those who do not conform.

Authorities employ various mechanisms to regulate (encouraging or discouraging) certain behaviors in general. Governing or administering agencies may for example codify rules into laws, police citizens and visitors to ensure that they comply with those laws, and implement other policies and practices that legislators or administrators have prescribed with the aim of discouraging or preventing crime. In addition, authorities provide remedies and sanctions, and collectively these constitute a criminal justice system. Legal sanctions vary widely in their severity; they may include (for example) incarceration of temporary character aimed at reforming the convict. Some jurisdictions have penal codes written to inflict permanent harsh punishments: legal mutilation, capital punishment or life without parole.

Usually, a natural person perpetrates a crime, but legal persons may also commit crimes. Conversely, at least under U.S. law, nonpersons such as animals cannot commit crimes.

The sociologist Richard Quinney has written about the relationship between society and crime. When Quinney states "crime is a social phenomenon" he envisages both how individuals conceive crime and how populations perceive it, based on societal norms.

Definition

England and Wales

Whether a given act or omission constitutes a crime does not depend on the nature of that act or omission. It depends on the nature of the legal consequences that may follow it. An act or omission is a crime if it is capable of being followed by what are called criminal proceedings.

History

The following definition of "crime" was provided by the Prevention of Crimes Act 1871, and applied for the purposes of section 10 of the Prevention of Crime Act 1908:

The expression "crime" means, in England and Ireland, any felony or the offence of uttering false or counterfeit coin, or of possessing counterfeit gold or silver coin, or the offence of obtaining goods or money by false pretences, or the offence of conspiracy to defraud, or any misdemeanour under the fifty-eighth section of the Larceny Act, 1861.

Scotland

For the purpose of section 243 of the Trade Union and Labour Relations (Consolidation) Act 1992, a crime means an offence punishable on indictment, or an offence punishable on summary conviction, and for the commission of which the offender is liable under the statute making the offence punishable to be imprisoned either absolutely or at the discretion of the court as an alternative for some other punishment.

Sociology

A normative definition views crime as deviant behaviour that violates prevailing norms – cultural standards prescribing how humans ought to behave normally. This approach considers the complex realities surrounding the concept of crime and seeks to understand how changing social, political, psychological, and economic conditions may affect changing definitions of crime and the form of the legal, law-enforcement, and penal responses made by society.

These structural realities remain fluid and often contentious. For example: as cultures change and the political environment shifts, societies may criminalise or decriminalise certain behaviours, which directly affects the statistical crime rates, influence the allocation of resources for the enforcement of laws, and (re-)influence the general public opinion.

Similarly, changes in the collection and/or calculation of data on crime may affect the public perceptions of the extent of any given "crime problem". All such adjustments to crime statistics, allied with the experience of people in their everyday lives, shape attitudes on the extent to which the State should use law or social engineering to enforce or encourage any particular social norm. Behaviour can be controlled and influenced by a society in many ways without having to resort to the criminal justice system.

Indeed, in those cases where no clear consensus exists on a given norm, the drafting of criminal law by the group in power to prohibit the behaviour of another group may seem to some observers an improper limitation of the second group's freedom, and the ordinary members of society have less respect for the law or laws in general – whether the authorities actually enforce the disputed law or not.

Other definitions

Legislatures can pass laws (called *mala prohibita*) that define crimes against social norms. These laws vary from time to time and from place to place: note variations in gambling laws, for example, and the prohibition or encouragement of duelling in history. Other crimes, called *mala in se*, count as outlawed in almost all societies, (murder, theft and rape, for example).

English criminal law and the related criminal law of Commonwealth countries can define offences that the courts alone have developed over the years, without any actual legislation: common law offences. The courts used the concept of *malum in se* to develop various common law offences.

Criminalization

One can view criminalization as a procedure deployed by society as a preemptive harm-reduction device, using the threat of punishment as a deterrent to anyone proposing to engage in the behavior causing harm. The State becomes involved because governing entities can become convinced that the costs of not criminalizing (through allowing the harms to continue unabated) outweigh the costs of criminalizing it (restricting individual liberty, for example, to minimize harm to others).

States control the process of criminalization because:

- Even if victims recognize their own role as victims, they may not have the resources to investigate and seek legal redress for the injuries suffered: the enforcers formally appointed by the State often have better access to expertise and resources.
- The victims may only want compensation for the injuries suffered, while remaining indifferent to a possible desire for deterrence.
- Fear of retaliation may deter victims or witnesses of crimes from taking any action. Even in policed societies, fear may inhibit from reporting incidents or from co-operating in a trial.
- Victims, on their own, may lack the economies of scale that could allow them to administer a penal system, let alone to collect any fines levied by a court. Garoupa & Klerman (2002) warn that a rent-seeking government has as its primary motivation to maximize revenue and so, if offenders have sufficient wealth, a rent-seeking government will act more aggressively than a social-welfare-maximizing government in enforcing laws against minor crimes (usually with a fixed penalty such as parking and routine traffic violations), but more laxly in enforcing laws against major crimes.
- As a result of the crime, victims may die or become incapacitated.

Labelling theory

The label of "crime" and the accompanying social stigma normally confine their scope to those activities seen as injurious to the general population or to the State, including some that cause serious loss or damage to individuals. Those who apply the labels of "crime" or "criminal" intend to assert the hegemony of a dominant population, or to reflect a consensus of condemnation for the identified

behavior and to justify any punishments prescribed by the State (in the event that standard processing tries and convicts an accused person of a crime).

Natural law theory

Justifying the State's use of force to coerce compliance with its laws has proven a consistent theoretical problem. One of the earliest justifications involved the theory of natural law. This posits that the nature of the world or of human beings underlies the standards of morality or constructs them. Thomas Aquinas wrote in the 13th century: "the rule and measure of human acts is the reason, which is the first principle of human acts" (Aquinas, ST I-II, Q.90, A.I). He regarded people as by nature rational beings, concluding that it becomes morally appropriate that they should behave in a way that conforms to their rational nature. Thus, to be valid, any law must conform to natural law and coercing people to conform to that law is morally acceptable. In the 1760s William Blackstone(1779: 41) described the thesis:

"This law of nature, being co-eval with mankind and dictated by God himself, is of course superior in obligation to any other. It is binding over all the globe, in all countries, and at all times: no human laws are of any validity, if contrary to this; and such of them as are valid derive all their force, and all their authority, mediately or immediately, from this original."

But John Austin (1790–1859), an early positivist, applied utilitarianism in accepting the calculating nature of human beings and the existence of an objective morality. He denied that the legal validity of a norm depends on whether its content conforms to morality. Thus in Austinian terms, a moral code can objectively determine what people ought to do, the law can embody whatever norms the legislature decrees to achieve social utility, but every individual remains free to choose what to do. Similarly, Hart (1961) saw the law as an aspect of sovereignty, with lawmakers able to adopt any law as a means to a moral end.

Thus the necessary and sufficient conditions for the truth of a proposition of law simply involved internal logic and consistency, and that the state's agents used state power with responsibility. Ronald Dworkin (2005) rejects Hart's theory and proposes that all individuals should expect the equal respect and concern of those who govern them as a fundamental political right. He offers a theory of compliance overlaid by a theory of deference (the citizen's duty to obey the law) and a theory of enforcement, which identifies the legitimate goals of enforcement and punishment. Legislation must conform to a theory of legitimacy, which describes the circumstances under which a particular person or group is entitled to make law, and a theory of legislative justice, which describes the law they are entitled or obliged to make.

Indeed, despite everything, the majority of natural-law theorists have accepted the idea of enforcing the prevailing morality as a primary function of the law. This view entails the problem that it makes any moral criticism of the law impossible: if conformity with natural law forms a necessary condition for legal validity, all valid law must, by definition, count as morally just. Thus, on this line of reasoning, the legal validity of a norm necessarily entails its moral justice.

One can solve this problem by granting some degree of moral relativism and accepting that norms may evolve over time and, therefore, one can criticize the continued enforcement of old laws in the light of the current norms. People may find such law acceptable, but the use of State power to coerce citizens to comply with that law lacks moral justification. More recent conceptions of the theory characterise crime as the violation of individual rights.

Since society considers so many rights as natural (hence the term "right") rather than man-made, what constitutes a crime also counts as natural, in contrast to laws (seen as man-made). Adam Smith illustrates this view, saying that a smuggler would be an excellent citizen, "...had not the laws of his country made that a crime which nature never meant to be so."

Natural-law theory therefore distinguishes between "criminality" (which derives from human nature) and "illegality" (which originates with the interests of those in power). Lawyers sometimes express the two concepts with the phrases *malum in se* and *malum prohibitum* respectively. They regard a "crime *malum in se*" as inherently criminal; whereas a "crime *malum prohibitum*" (the argument goes) counts as criminal only because the law has decreed it so.

It follows from this view that one can perform an illegal act without committing a crime, while a criminal act could be perfectly legal. Many Enlightenment thinkers (such as Adam Smith and the American Founding Fathers) subscribed to this view to some extent, and it remains influential among so-called classical liberals and libertarians.

Classification and categorisation

Categorisation by type

The following classes of offences are used, or have been used, as legal terms:

- Offence against the person
- Violent offence
- Sexual offence
- Offence against property

Researchers and commentators have classified crimes into the following categories, in addition to those above:

- Forgery, personation and cheating
- Firearms and offensive weapons
- Offences against the State/offences against the Crown and Government/political offences
- Harmful or dangerous drugs
- Offences against religion and public worship
- Offences against public justice/offences against the administration of public justice
- Public order offence
- Commerce, financial markets and insolvency
- Offences against public morals and public policy
- Motor vehicle offences
- Conspiracy, incitement and attempt to commit crime
- Inchoate offence
- Juvenile delinquency
- Victimless crime

Categorisation by penalty

One can categorise crimes depending on the related punishment, with sentencing tariffs prescribed in line with the perceived seriousness of the offence. Thus fines and noncustodial sentences may address the crimes seen as least serious, with lengthy imprisonment or (in some jurisdictions) capital punishment reserved for the most serious.

Common law

Under the common law of England, crimes were classified as either treason, felony or misdemeanour, with treason sometimes being included with the felonies. This system was based on the perceived seriousness of the offence. It is still used in the United States but the distinction between felony and misdemeanour is abolished in England and Wales and Northern Ireland.

Classification by mode of trial

The following classes of offence are based on mode of trial:

- Indictable-only offence
- Indictable offence
- Hybrid offence, a.k.a. either-way offence in England and Wales
- Summary offence, a.k.a. infraction in the US

Classification by origin

In common law countries, crimes may be categorised into common law offences and statutory offences. In the US, Australia and Canada (in particular), they are divided into federal crimes and under state crimes.

Other classifications

- Arrestable offence

U.S. classification

In the United States since 1930, the FBI has tabulated Uniform Crime Reports (UCR) annually from crime data submitted by law enforcement agencies across the United States. Officials compile this data at the city, county, and state levels into the UCR. They classify violations of laws based on common law as Part I (index) crimes in UCR data. These are further categorized as violent or property crimes. Part I violent crimes include murder and criminal homicide (voluntary manslaughter), forcible rape, aggravated assault, and robbery; while Part I property crimes include burglary, arson, larceny/theft, and motor-vehicle theft. All other crimes count come under Part II.

For convenience, such lists usually include infractions although, in the U.S., they may come into the sphere not of the criminal law, but rather of the civil law. Compare tortfeasance.

Booking arrests require detention for a time-frame ranging 1 to 24 hours.

Reports, studies and organization

There are several national and International organizations offering studies and statistics about global and local crime activity, such as United Nations Office on Drugs and Crime, the United States of

America Overseas Security Advisory Council (OSAC) safety report or national reports generated by the law-enforcement authorities of EU state member reported to the Europol.

Offence in common law jurisdiction

In England and Wales, as well as in Hong Kong, the term "offence" means the same thing as, and is interchangeable with, the term "crime". They are further split into:

- Summary offences
- Indictable offences

Causes and correlates of crime

Many different causes and correlates of crime have been proposed with varying degree of empirical support. They include socioeconomic, psychological, biological, and behavioral factors. Controversial topics include media violence research and effects of gun politics.

Emotional state (both chronic and current) have a tremendous impact on individual thought processes and, as a result, can be linked to criminal activities. The positive psychology concept of Broaden and Build posits that cognitive functioning expands when an individual is in a good-feeling emotional state and contracts as emotional state declines. In positive emotional states an individual is able to consider more possible solutions to problems, but in lower emotional states fewer solutions can be ascertained. The narrowed thought-action repertoires can result in the only paths perceptible to an individual being ones they would never use if they saw an alternative, but if they can't conceive of the alternatives that carry less risk they will choose one that they can see. Criminals who commit even the most horrendous of crimes, such as mass murders, did not see another solution.

Crimes in international law

Crimes defined by treaty as crimes against international law include:

- Crimes against peace
- Crimes of apartheid
- Forced disappearance
- Genocide
- Piracy
- Sexual slavery
- Slavery
- Waging a war of aggression
- War crimes

From the point of view of state-centric law, extraordinary procedures (usually international courts) may prosecute such crimes. Note the role of the International Criminal Court at The Hague in the Netherlands.

Religion and crime

Different religious traditions may promote distinct norms of behaviour, and these in turn may clash or harmonise with the perceived interests of a state. Socially accepted or imposed religious morality has influenced secular jurisdictions on issues that may otherwise concern only an individual's conscience. Activities sometimes criminalized on religious grounds include (for example) alcohol consumption (prohibition), abortion and stem-cell research. In various historical and present-day societies, institutionalized religions have established systems of earthly justice that punish crimes against the divine will and against specific devotional, organizational and other rules under specific codes, such as Roman Catholic canon law.

Military jurisdiction and states of emergency

In the military sphere, authorities can prosecute both regular crimes and specific acts (such as mutiny or desertion) under martial-law codes that either supplant or extend civil codes in times of (for example) war.

Many constitutions contain provisions to curtail freedoms and criminalize otherwise tolerated behaviors under a state of emergency in the event of war, natural disaster or civil unrest. Undesired activities at such times may include assembly in the streets, violation of curfew, or possession of firearms.

Employee crime

Two common types of employee crime exist: embezzlement and wage theft.

The complexity and anonymity of computer systems may help criminal employees camouflage their operations. The victims of the most costly scams include banks, brokerage houses, insurance companies, and other large financial institutions.

In the United States, it is estimated that workers are not paid at least \$19 billion every year in overtime and that in total \$40 billion to \$60 billion are lost annually due to all forms of wage theft. This compares to national annual losses of \$340 million due to robbery, \$4.1 billion due to burglary, \$5.3 billion due to larceny, and \$3.8 billion due to auto theft in 2012. In Singapore, as in the United States, wage theft was found to be widespread and severe. In a 2014 survey it was found that as many as one-third of low wage male foreign workers in Singapore, or about 130,000, were affected by wage theft from partial to full denial of pay (Crime).

UNIT-16

MANAGEMENT OF HAZARDS AND DISASTERS

Mitigation

Mitigation refers to the policies and activities that attempt to reduce and/or eliminate individual and/or community vulnerability to damage from future disasters. Mitigation measures seek to “treat” the hazard such that it impacts individuals and communities to a lesser degree. Thus natural hazards have the potential to become disasters in the absence of mitigation measures. For this reason, the Federal Emergency Management Authority (FEMA) in the United States considers mitigation as the “cornerstone of disaster management” and it has defined mitigation as: “any cost-effective action taken to eliminate or reduce the long-term risk of life and property from natural and technological

hazards” (FEMA, n.d., p. 1). The phrase “cost-effective” is added to this definition to stress that a mitigation measure should save money over the long term. Since the 1970s there has been a growing interest in disaster mitigation programs from both public and private agencies. There is a large body of literature which urges governments to reallocate at least part of their budget from relief to mitigation.

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Mitigation goals

According to Coppola (2007), there are five major mitigation goals: risk likelihood reduction, risk consequences reduction, risk avoidance, risk acceptance, and risk transfer, sharing, or spreading. These goals are closely associated with the phrase “alternative adjustments to natural hazards” or “theoretical range of adjustments to geophysical events” used in hazard geography (Burton *et al.*, 1968; Smith, 1992). Adjustments are defined as those human activities or measures intended to reduce or minimize negative impacts of an extreme event (White, 1974). These measures may be grouped in many different ways. Burton *et al.* (1968) for examples, classified these measures as: (i) affect in the cause, (ii) modifying the hazard, (iii) modifying loss potential or burden, (iv) an adjustment to losses

by spreading out the losses, (v) planning for losses, and (vi) bearing the losses. The goals of mitigations are briefly discussed below.

Risk likelihood reduction

It is possible to reduce the likelihood of occurrence for several hazards. For example, flood frequency can be reduced through constructing dams, dikes, levees, flood walls, and bayous. These measures keep water away from the people up to the design stage of the structure. For some hazards, such as hurricanes and earthquakes, such interventions are not technically possible, at least at present. Mitigation measures that seek to reduce risk likelihood tend to be both structural and nonstructural in nature. The former measures use technological solutions, like dams and levees, while nonstructural measures include legislation, land use planning (e.g., the designation of nonessential land like parks to be used as flood zones), and insurance.

Risk consequences reduction

This goal acknowledges the fact that most disasters are unavoidable, but their consequences can be reduced through adopting mitigation measures such as the construction of safe rooms or public cyclone shelters. Since 1998, FEMA has recommended building safe rooms in tornado-prone areas in the United States. These are rooms that are anchored and armored to provide safe shelter during even the strongest of storms. They are made with thick concrete walls and a ceiling reinforced with steel bars. A safe room can be installed in a basement, in the center of the ground level of homes without a basement, or under a garage, the garage floor serving as the ceiling. One can also dig out a space beneath a reinforced entryway, using the large concrete slabs as protection from above (Murphy and Sherry, 2003). In the United States, safe rooms are in great demand in the tornado-prone state of Oklahoma, where basements are uncommon because of the ubiquitous hard clay soils (Murphy and Sherry, 2003). However, even a basement is no guarantee of protection from tornadoes for several reasons. Many basements, for example, are not fully underground, which makes them vulnerable to a degree. In addition, most basements have a wood floor overhead that could collapse when subjected to tornado-force winds. Public shelters are necessary in areas where disasters such as tornadoes or hurricanes/cyclones are likely. In the United States, it is desirable, but not often present to have community storm shelters near mobile/manufactured home parks. Mobile homes are highly vulnerable in tornado-prone areas. From 1985 to 2007, 43% of all tornado fatalities occurred in mobile/manufactured homes, yet these types of homes made up less than 8% of housing in the tornado-prone areas studied (Sutter and Poitras, 2010). In 1972, the Bangladesh government began constructing public cyclone shelters in coastal areas to help save lives of coastal residents from cyclones and associated storm surges. These shelters are multi-storied reinforced concrete buildings, raised above ground level (to resist storm surges) and can accommodate 1500–2500 people (Paul *et al.*, 2002). Figure 5.2 illustrates a typical shelter built in the 1970s in coastal Bangladesh. Most of these cyclone shelters are used for multiple purposes during normal and disaster periods. In nondisaster periods, some of these buildings are used as schools, community centers, government

offices, and elected local government (i.e., union council) offices. Many government development activities are also carried out in these shelters and are connected with surrounding neighbourhoods with flood-resistant access routes. Coastal embankments are another mitigation measure implemented in Bangladesh to reduce or prevent damage from cyclones and associated storm surges. The height of these embankments ranges from 17 to 20 feet (5–6 m) and they have marine and land-side slopes of 1:7 and 1:3, respectively. The Bangladesh government has also initiated a large afforestation project to provide protection for coastal residents and the beach environment against tidal and storm surges (Government of Bangladesh, 2008). Thus, some hazards have more than one option for disaster consequences reduction. Like the first goal, these measures tend to be both structural and nonstructural. The former includes both new and reinforced structures, which are able to withstand the negative impacts of disasters. These structures make it possible to live in cyclone-prone high-risk areas. Nonstructural measures include hazard forecasting and warning systems, and evacuation of potential victims from the projected path of an impending disaster. The risk consequences reduction goal also includes public awareness programs that provide residents with information on what to expect, what to do, and when to take action during an advancing disaster. Another way to reduce the consequences associated with a disaster is by identifying hazard zones and restricting or regulating their development (Coppola, 2007; Tobin and Montz, 1997).

Risk avoidance

The third mitigation goal is appropriate for disasters whose risks are great even after a partial reduction in either their likelihood or consequences. For these disasters total avoidance is necessary. This usually involves permanent evacuation of people and/or relocation of structures from a high-risk zone to a low- or no risk zone. Out-migration and buyout programs are examples of risk avoidance mitigation measures. The latter program seeks to physically remove people and structures within a floodplain and then restrict all future construction in that reclaimed land. Risk avoidance is also possible through relocation from volcanoes, avalanche chutes, and landslide zones.

Risk acceptance

This goal of mitigation is similar to adjustments which have been termed “bear the losses” – where people are willing to bear the full burden of damage or share it in some fashion with others (Burton *et al.*, 1968). No or extremely few places on the earth’s surface are free from natural hazards. A place may not experience all disaster types, but most locales are subject to a select number of hazards. Residents of such places expect these hazards and they generally accept a certain risk associated with the disaster. For example, residents of floodplains expect river flooding and they are willing to bear some damage associated with flooding. It is to be noted that river flooding also has some benefits, such as increasing soil fertility due to the deposition of nutrient-rich silt. People who accept losses usually do not attempt to alter the cause(s) of disasters. They bear associated losses for several reasons. Often they perform a cost–benefit analysis and find out that an intended reduction measure for a particular hazard is not cost effective. In such a case, they will not pursue that particular

measure, but may pursue a similar measure for other hazards for which that particular risk reduction measure will have greater value relative to losses usually incurred. Second, often some reduction mitigation measures will result in one or more undesirable consequences. Such a consequence may be considered more damaging or undesirable than impacts resulting from the hazard itself. Finally, for cultural or other reasons, residents of a particular place and location may prefer to stay there despite certain risks (Coppola, 2007).

Risk transfer, sharing, or spreading

The last and most debated mitigation goal is risk transfer, sharing, or spreading of financial losses incurred by disasters. Depending on the availability of disaster insurance, disaster-impacted communities and individuals can spread or transfer disaster loss or risk through insurance coverage. Insurance reduces the financial consequences of a disaster by transferring at least part of any monetary loss of property. It is important to mention that disaster insurance is still not available in many developing countries. Wherever it is available, coverage by insurance may be wholly voluntary or wholly mandatory, and large businesses often self-insure by setting up reserves and diversifying. However, in the United States, federal policy is aimed at encouraging local governments and individuals to insure public and private property against losses due to extreme natural events. The National Flood Insurance Program (NFIP) requires residents of flood-prone communities to carry flood insurance. Another way to transfer, share, or spread disaster loss is through the provision of relief and rehabilitation assistance, which is more common in developing countries than in developed countries. This assistance is generally offered to disaster victims by both public and private agencies. However, the availability of emergency relief may work against adoption of insurance by prospective disaster victims. Other ways to offset disaster losses include help from friends and relatives in various forms, such as cash, in kind, and labor. This is closely associated with the concept of social capital theory, which is defined by Pierre Bourdieu as the resources that can be derived through one's social network. It refers to the collective value of all "social networks" and the inclinations that arise from these networks to assist each other (Bourdieu, 1985).

Mitigation measure classification

As indicated, there are hundreds of mitigation measures which range from physical measures such as flood levees or safer building designs to nonphysical measures including legislation, training, and even public awareness campaign. Each hazard has a unique set of mitigation options from which disaster managers may choose to engage/develop. Selection of mitigation options depend on costs, available funds, as well as the anticipated social and physical consequences of taking such actions. Mitigation measures can be classified in many different ways. For example, Mileti (1999) classified mitigation measures into five groups: land use planning/regulation, building codes and standards, insurance, engineering, and warning.

Land use planning and regulation

The main purpose of this measure is to reduce hazard exposure by land use management or zoning, and restricting construction of structures in hazard-prone areas. This is a regulatory measure where local government is responsible for preparing and following through land use planning and regulation for development in hazard-prone areas, prohibiting new construction in a floodplain, along a coast, or any other hazards-prone area. Among others, land use planning and regulation activities include enforcement of building codes and environmental regulations; public safety measures such as continual maintenance of roadways, culverts and dams; acquisition or relocation of properties such as purchasing buildings located in a floodplain; and retrofitting of structures and design of new construction such as elevating a home or building. Hazard-prone communities across the globe have implemented many regulatory and land use zoning mitigation measures. For example, after experiencing an F-4 tornado on April 21, 2001, the city of Hoisington, Kansas, enforced two new zoning ordinances that restricted the construction of homes on 50-foot lots in tornado-impacted portions of the city. This enforcement meant residents who were rebuilding had to purchase adjacent lots in order to satisfy the newly established requirements. As a result, housing density in the tornado-affected area became significantly lower than pre-tornado density and is also now lower than in non-impacted portion of the city (Brock and Paul, 2003). This ordinance has reduced exposure by limiting development and density of human occupancy in Hoisington.

Another new zoning regulation that went into effect in Hoisington was that any house constructed west of Alexandria Street could not have a basement because that area was identified by FEMA as being in a floodplain zone. Since everyone wanting to rebuild desired a basement, no one rebuilt their homes in that area. The city then bought this land and converted it into a park with new playground equipment and tennis courts. This change in land use was welcomed by an overwhelming majority of the residents of Hoisington – a town with a population of about 2000 in 2000 (Brock and Paul, 2003). Similarly, Cedar Falls, Iowa, a city of 36 145 people in 2000, bought 128 homes that were severely affected by a flood in 2008. Another 81 homes are in the process of being acquired by the city. All buyout properties will be used as a park or designated as a protected area (Rahman, 2010). In another example of reduced exposure through land use change, several small communities were relocated away from flood-prone areas after the widespread flooding experienced in the US Midwest in 1993 (Mileti, 1999). Most hazard regulatory measures are initiated by the central government, but such measures are often implemented by the local government. However, local governments are often reluctant to implement strict land use policies and regulatory measures due to a lack of local political will to manage land use, and/or deficiencies in management capacity. Because the spatial extent of different natural hazards is usually well defined, land use planning and regulatory measures are particularly appropriate for specific geographic designations, such as flood plain and coastal zone management.

Building codes and standards

Building codes are a collection of laws, regulations, ordinances, or other statutory requirements adopted by a governmental legislative authority regarding the physical structure and/or construction of buildings. This group of mitigation measures is designed to ensure that structures resist the physical impacts created

by disasters and their purpose is to establish minimum acceptable requirements necessary for preserving the public health, safety, and welfare as well as the protection of property in the built environment. The primary application of building codes is to regulate new or proposed construction (Mileti, 1999). Although such codes may have little application to existing buildings (unless they are undergoing alteration), the effectiveness of zoning and other regulatory measures can be enhanced through the use of building codes.

Insurance

Most property owners in developed countries rely on private insurance to protect themselves against financial losses from some, but usually not all, natural disasters. Although insurance does not reduce actual disaster consequences or reduce hazard likelihood, it allows associated economic losses to be shared across a wide population. It should be noted that insurance often offers no incentives to undertake mitigation.

Engineering

This type of mitigation is frequently called structural mitigation, and involves physical measures taken to reduce disaster risk by erecting structures, such as cross-dams, and building a tornado safe room. Engineering measures also attempt to strengthen buildings to better withstand future disasters, such as tornadoes and earthquakes. This can be accomplished in two ways: the structure maybe demolished and rebuilt to accommodate new hazard information or it may be modified so that it resists the anticipated external force (retrofitting). Thus, structural measures involve measures that relate to the existing natural and built environments and/or which address future developments.

Warning

A warning system is necessary to detect an impending disaster, communicate that information to people at risk, and encourage at risk population to take appropriate action. Disaster warning systems can make the difference between life and death. Lindell *et al.* (2005) maintain that the remarkable reduction in US hurricane casualties since the 1900 Galveston hurricane was due to improved forecasting and warning systems coupled with timely and effective evacuations of coastal residents from imminent threats. However, in many countries, no comprehensive national warning system is available that covers all hazards and all places within a given country.

Critique of mitigation

There are several criticisms of mitigation. Mitigation projects tend to be large scale and high technology oriented, and thus very costly. Finding the fund to implement projects is often very challenging. A top-down approach is generally used to design and implement such projects. Mitigation projects are generally developed and managed by large centralized agencies without seeking input from disaster survivors. Because of their top-down approach, mitigation projects generally favor the rich and powerful at the expense of the most vulnerable. The emphasis of most mitigation programs has been on physical measures to address the immediate threat of a natural hazard and not on social changes to address the problem. Such programs only deal with reducing the risks of specific hazards and not on reducing the vulnerability of marginalized groups. So far, mitigation strategies have been designed to reduce the probability and impact of hazards, along with implementing anti-exposure measures, such as restricting development in floodplain zones. Anti-vulnerability mitigation measures (e.g., land reform and poverty alleviation) have received little, if any attention among hazard researchers as a means to reduce hazard risk. Reduction in vulnerability is necessary to build future resilience against hazards and disasters. Also, mitigation programs often do not take into account all the actual needs and demands of those affected by disasters. One of the greatest obstacles to mitigation is that those most impacted by a disaster often resist any alteration to their place of residence by land use changes and/or imposing new regulations for construction, including amending building codes. Citizens may have a vision of their community, their property, or their home that they are reluctant to alter. However, there are important reasons to mitigate against hazards. The most important is that it makes communities safer places to live. Increased safety brings a host of benefits that become apparent after a disaster, for example the cost of reconstruction is lower and the time it takes is shorter; businesses close for less time; public facilities require fewer repairs; and the community is running again sooner. In the long term, the community will be subject to fewer disasters.

Preparedness

Preparedness refers to the degree of alertness and readiness of an individual, a household, or a community against an impending disaster. Among many activities, preparedness includes such activities as formulating, testing and exercising disaster plans, providing hazard warnings, communicating with the public and others regarding disaster vulnerability and what to do to reduce it, evacuating people from harms way, conducting emergency response drills, and providing disaster training for emergency responders and the general public (Tierney *et al.*, 2001). The acquisition of equipment to support emergency action is also an important activity of hazard preparedness. Such activities ensure that the resources necessary for carrying out an effective response in shortest possible time are in place prior to the onset of a disaster or that they can be obtained promptly when needed. Preparedness minimizes the negative consequences of extreme events. It does not only facilitate effective response, but also enhances the ability of social units to effectively respond when a disaster does occur. Hazard preparedness is often divided into two categories: physical preparedness and social preparedness (Tierney *et al.*, 2001). The former centers on taking actions to ensure that facilities and structures can withstand disaster impacts and the buildings and their contents do not

become a serious threat to life and property should a disaster strikes. Social preparedness includes actions (e.g., understanding what state and federal programs are available at the time of disaster, planning for situations involving hazard warning and evacuation, establishing emergency record-keeping systems, and developing disaster plans) to ensure that community organizations are able to adequately respond to the needs of victims in the event of a disaster. Both physical and social preparedness are seen as part of a five-phase preparedness cycle that consists of: (i) raising awareness, (ii) conducting hazards and vulnerability assessments, (iii) improving knowledge about hazard and how to cope with them, (iv) planning, and (v) practice (Tierney *et al.*, 2001). The preparedness process usually begins with a vulnerability analysis that attempts to identify what hazards could occur in a particular place and a risk analysis to determine the likely problems that an extreme event could impose. Numerous public and private emergency response agencies as well as individuals conduct disaster preparedness activities. Each agency and personnel has unique functions to perform and unique responsibilities to accomplish before disasters strike. Others along the path of an impending hazard need to be compliant with the directions provided by emergency management personnel.

Activities

As indicated, preparedness includes a range of activities and/or actions that are undertaken (at different levels) immediately and/or any time before a disaster which saves lives and minimize property damage. A number of preparedness activities are discussed below. This discussion is followed by an analysis of preparedness activities at four distinct levels: households, organizations, communities, and state and national preparedness. Factors that influence preparedness at each of these levels is also discussed.

Warning

Hazard warnings include a range of activities such as effective monitoring and accurate forecasting of a forthcoming event, developing warning messages, and disseminating the messages to those at risk. Before issuing a hazard warning, responsible authorities must identify what hazard is about to occur, is currently happening, or has already taken place. Detection and emergency assessment procedures differ by hazard types.

Evacuation

Evacuation is the primary protective action utilized in disasters such as floods, tsunamis, large wildfires, hurricanes/cyclones, and volcanic eruptions. It refers to the movement of people away from a potential or actual hazard impact area for the primary purpose of ensuring safety. Evacuation can take place before, during, or after a disaster occurs.

Exercise

One of the most effective ways to prepare for a disaster is to conduct practice exercises on a regular basis. The primary goal of such exercises is to improve operational readiness for people who participate in disaster response and recovery efforts. Exercises enhance a community's overall emergency management capabilities and provide useful tools for local programs to train emergency personnel and evaluate their operational readiness. Through exercises it is possible to identify shortcomings of emergency operations plans (EOP), reveal resource gaps, improve coordination and individual performance, and clarify roles and responsibilities of personnel involved in disaster activities. Disaster exercises also foster cooperation among government agencies and private sector resources, increase general awareness of proficiencies and needs, and verify the availability and utility of equipment (McEntire, 2007).

Household preparedness

Household level preparedness activities include: developing an emergency plan for the household, discussing preparedness plan (evacuation route) with family members, storing food and water, securing the home and contents, having a first-aid kit at home, making sure that there is a battery-powered radio on hand and a working flashlight, and taking other steps to prepare and anticipate whatever problems a disaster might create. Purchasing hazard insurance and making structural changes to the home are also household-level preparedness activities. Such household preparedness activities are disaster-specific.

Organizational preparedness

Both public and private organizations have disasters preparedness programs. Preparedness activities of these organizations include: developing emergency response plans and warning systems, identifying evacuation routes and shelters, acquiring needed equipment, supplies and materials, and maintaining emergency supplies and communication systems. Other preparedness activities include notifying and mobilizing key personnel, training employees and response personnel on what to do in an emergency situation, conducting exercises and drills, and informing citizens of risks, preparedness options, as well as the content and meaning of warning messages through education programs. There has been a tendency to focus on organizational preparedness only for specific kinds of hazards; this needs to be broadened to include all citizens as well as all hazards they might be impacted by.

Community preparedness

Like household and organizational preparedness, community preparedness encompasses a wide range of activity such as formulating plans, providing training for disaster responders and the general public to improve their understanding of what to do in a disaster, and conducting emergency drills and exercises.

State and national preparedness

In a country such as the United States where a federal system of government exists, state government plays a key role in disaster preparedness, both supporting communities impacted by disasters and coordinating with the federal government on a wide range of disaster-related tasks (Tierney *et al.*, 2001). State governments are required to develop their own disaster plans (Paul, 2011).

1.7 SELF-ASSESSMENT TEST

- Define resource. Differentiate between conventional and non-conventional resources.
- Give an account of world distribution of coal with special reference to India.
- Give an account of world distribution of mineral oil with special reference to India.
- Elucidate the concept of hazards and disasters. Explain the mechanism of tropical cyclone and their impact with reference to West Bengal.

1.8 SUMMARIES AND KEY POINTS

The present section introduces the concept and classification of resources, conventional and non-conventional resources. It discusses the distribution of energy resources- coal and mineral oil. It discusses the issues regarding Crisis, conservation and management of resource. It provides an overview of major economic activities- primary, secondary and tertiary activities. It discusses the concept of hazards and disasters; Physical hazards: tropical cyclone, flood, land slide with reference to West Bengal. It discusses the meaning of social hazards: poverty and crime. Finally it discusses about management of hazards and disasters

1.9 STUDY TIPS

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NOTES

Post-Graduate Degree Programme (CBCS)
in
GEOGRAPHY

Semester-II

Paper: GEO206T

Self-Learning Material



DIRECTORATE OF OPEN AND DISTANCE LEARNING
UNIVERSITY OF KALYANI
Kalyani, Nadia
West Bengal, India

COURSE MATERIAL COMPILED BY

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Director's Message

Satisfying the varied needs of distance learners, overcoming the obstacle of distance and reaching the unreached students are the threefold functions catered by Open and Distance Learning (ODL) systems. The onus lies on writers, editors, production professionals and other personnel involved in the process to overcome the challenges inherent to curriculum design and production of relevant Self Learning Materials (SLMs). At the University of Kalyani a dedicated team under the able guidance of the Hon'ble Vice-Chancellor has invested its best efforts, professionally and in keeping with the demands of Post Graduate CBCS Programmes in Distance Mode to devise a self-sufficient curriculum for each course offered by the Directorate of Open and Distance Learning (DODL), University of Kalyani.

Development of printed SLMs for students admitted to the DODL within a limited time to cater to the academic requirements of the Course as per standards set by Distance Education Bureau of the University Grants Commission, New Delhi, India under Open and Distance Mode UGC Regulations, 2017 had been our endeavour. We are happy to have achieved our goal.

Utmost care and precision have been ensured in the development of the SLMs, making them useful to the learners, besides avoiding errors as far as practicable. Further suggestions from the stakeholders in this would be welcome.

During the production-process of the SLMs, the team continuously received positive stimulations and feedback from Professor (Dr.) Sankar Kumar Ghosh, Hon'ble Vice- Chancellor, University of Kalyani, who kindly accorded directions, encouragements and suggestions, offered constructive criticism to develop it within proper requirements. We gracefully, acknowledge his inspiration and guidance.

Sincere gratitude is due to the respective chairpersons as well as each and every member of PGBOS (DODL), University of Kalyani. Heartfelt thanks is also due to the Course Writers-faculty members at the DODL, subject-experts serving at University Post Graduate departments and also to the authors and academicians whose academic contributions have enriched the SLMs. We humbly acknowledge their valuable academic contributions. I would especially like to convey gratitude to all other University dignitaries and personnel involved either at the conceptual or operational level of the DODL of University of Kalyani.

Their persistent and co-ordinated efforts have resulted in the compilation of comprehensive, learner-friendly, flexible texts that meet the curriculum requirements of the Post Graduate Programme through Distance Mode.

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Director
Directorate of Open and Distance Learning
University of Kalyani

SYLLABUS

SEMESTER-II

Paper – GEO206T

**(Total Credit – 4; Total Marks – 100: Internal Evaluation – 20,
Semester-end Examination - 80)**

GROUP – GEO206T.1: POPULATION GEOGRAPHY

(Credit – 2; Marks - 50: Internal Evaluation – 10 + Semester-end Examination - 40)

- Unit-1: Scope and Content of Population Geography
- Unit-2: Sources of Population Data
- Unit-3: Population Geography as Distinct from Demography
- Unit-4: Theories of Population Growth
- Unit-5: Factors Controlling Fertility, Mortality and Migration
- Unit-6: Demographic Transition Model; Limits to Growth
- Unit-7: Population Policies – Pro and Anti Natal
- Unit-8: Comparative Study of Population Policies between India and China

GROUP – GEO206T.2: SETTLEMENT GEOGRAPHY

(Credit – 2; Marks - 50: Internal Evaluation – 10 + Semester-end Examination - 40)

- Unit-9: Concept of Ekistics
- Unit-10: Study on Settlement Hierarchies
- Unit-11: Theories and Models of Settlement Study: Central Place, Rank-size Rule and Concept of Primacy
- Unit-12: Types, Pattern and Segregation of Rural Settlements in India
- Unit-13: Urban Definition: World and India
- Unit-14: Urbanization in India as Multi-dimensional Process
- Unit-15: Concept of Million cities, Mega cities, Megalopolis and Ecumenopolis
- Unit-16: Urban Sprawl, Urban Renewal and Rural-urban Continuum in Indian Context

Mode of Internal Examination: Multiple Choice Type Questions

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GROUP: GEO206T.1 – POPULATION GEOGRAPHY

(Credit – 2; Marks - 50: Internal Evaluation – 10 + Semester-end Examination - 40)

1.1 Introduction

Population geography is a branch of human geography. It is the study of the ways in which spatial variations in the distribution, composition, migration, and growth of populations are related to the nature of places. Population geography involves demography in a geographical perspective. It focuses on the characteristics of population distributions that change in a spatial context. This often involves factors such as where populations are found, how the size and composition of these populations is regulated by the demographic processes of fertility, mortality and migration. Contributions to population geography are cross-disciplinary because ‘geographical’ epistemologies related to environment; place and space have been developed during varying times. Some of these related disciplines include geography and demography, sociology, or economics.

1.2 Learning Objectives

After reading this self-learning material, the learners will be able

- to know the scopes and contents of Population Geography, sources of population data and how Population Geography makes it distinct from Demography.
- They will also be informed about the theories of population growth and be able to evaluate those theories at space-time scale.
- It will help them to explain the factors of population growth – fertility, mortality and migration.
- Learners will be able to know the different kinds of population policies rising from India and from China in a comparative mode.

1.3 Assessment of Prior Knowledge

For the purpose of assessment of prior knowledge on population geography of the students, the following questions may be asked:

- a) What are differences between population geography and demography?
- b) What are the principal components of population of an area?
- c) Why do population increase in a region?
- d) Why do population decrease in a region?
- e) What are the causes of population change in an area?
- f) What do they mean by fertility, fecundity, mortality and morbidity?

1.4 Learning Activities

During the Personal Contact Programmes, students may be assigned to prepare project on India's population growth since the Independence. They may also be requested to prepare charts and thematic maps on different issues such as female-male ratio, migration trend, occupational characteristics, literacy, rural-urban differentials etc. based on recent census data at state level of India. Projects may also be assigned on district level demographic analysis of the state of West Bengal using District Level Facility and household Survey.

1.5 Feedback of Learning Activities

To assess the feedback of the learning activities of students, internal assessment in the form of objective and subjective questions may be conducted. Besides, group discussion, debate etc. can be arranged. During feedback, problem areas would be identified and necessary steps would be taken up to resolve them.

2.0 Scope and content of Population Geography

The subject matter of population studies includes the study of fertility, mortality, migration and social mobility, that is, the components of change in the size, structure, characteristics and distribution of population. It explains the factors responsible for change in the size of population.

A student of population is engaged in describing and comparing the size, structure, characteristics and territorial distribution of the population, and the changes occurring in it through the study of fertility, mortality, migration and social mobility.

Population geography is a sub-discipline of Human geography and studies the distribution, concentration and density of population over the terrestrial surface, as well as differences in population size, changes and characteristics, like structures, migrations, activity etc., among some places present compared to others. Population geography has had a scientific stage as long as human history. First modern scientific treatise of population in geography was the F. Ratzel's book *Antropogeography* in 1882. During the first half of the twentieth century, French geographer Vidal de la Blanche gave a capital importance of population studies in his work *Principles de Geographie Humaine*. In inter-war years, various aspects of population were studied. After The Second World War, the renovating movement of geography was started and new tendencies appear in human geography and, consequently in population geography. Attempts were made to define population geography as a separate sub-discipline. The world-wide trend of treating population geography as separate discipline was expressed by publishing monographs, bibliographies and textbooks. The most significant authors who worked on defining population geography were French geographers P. George (1951, 1959), Beaujen-Garnier (1965, 1966); North-American geographers: G. Trewarta (1953, 1969), W. Bunge (1962), J. Clance (1965, 1971), W. Zelinski (1966); in Great Britain: J.I. Clarke (1965); in USSR: (1950), (1966), (1973); in Poland V. Ormotski (1931), L. Kosinski (1967) A. Jagelski (1980). Those authors and their works had the significant influence on the development of population science in the world and also in Serbia.

2.1 Scope

The scope of population studies is quite wide. The quantitative aspect is concerned with a quantitative study of the size, structural characteristics and territorial distribution of human populations and the changes occurring in them. Under the planned socialist economy, the practical tasks of population geography include quantitative and qualitative assessment of labour resources and a search for the

forms of settlement most responsive to the requirements of production, the cultural and domestic needs of the population. A study of the conditions of habitation in different natural geographic regions reveals the connections between population geography and medical geography. Research on ethnography and the economics of labour is closely associated, and sometimes intertwined with population geography. The development of methods of making population maps is very important. Hence, while describing, comparing or explaining the determinants and consequences of population phenomena, social phenomena have to be taken into consideration.

Population geography has a special place in economic geography because people, as the main productive force, are employed in all economic sectors and, up to a point their location has an all-encompassing significance. The population is at one and the same time the producer and consumer of material goods. Population geography studies, systems and structures—the forms of settlement in relation to the spatial nature of production, the characteristics of the geographical environment, the economic geographical condition of population employment, and population migrations. Together with differences in the natural growth of population, migrations determine the course of territorial redistribution of population. A prominent place is given to the classification and typology of populated points.

One statement that can be made without reservation is that the boundary between population geography and demography, sociology, or economics can be difficult to locate. The consensus is that demographers focus more on fertility research, whereas population geographers tend to focus on migration. With the advent of more-sophisticated methods, in particular those related to geographical information systems (GIS) or remote sensing, and the ever-increasing availability of data at multiple spatial scales, the fundamental importance of space and geography has become more main-stream in population studies across the social sciences. This evolution is apparent in the development of a multidisciplinary subfield called neither spatial demography nor pure demography.

2.2 Content

According to Trewartha, the contents of population geography can be grouped into three categories:

(1) A historical (pre-historic and post-historic) account of population: Trewartha suggested that where direct statistical evidence is not available, geographers should adopt indirect methods, and collaborate with anthropologists, demographers and economic historians.

(2) Dynamics of number, size, distribution and growth patterns: In Trewartha's opinion, an analysis of world population patterns, population dynamics in terms of mortality and fertility, area aspect of over and under population, distribution of population by world regions and settlement types and migration of population (both international and inter-regional) form an important part of analysis in population geography.

(3) Qualities of population and their regional distribution: He suggested two broad groups – physical qualities (e.g., race, sex, age, health etc.), and socio-economic qualities (e.g., religion, education, occupation, marital status, stages of economic development, customs, habits etc.).

Population geography studies the formation of the population in different territories in terms of structure, density, specific clustering (cities and rural communities), and the conditions that determine the particular forms of settlement.

The main concern of population geography revolves round the following three aspects of human population:

1. Size and distribution, including the rural-urban distribution of population.
2. Population dynamics – past and present trends in growth and its spatial manifestation; components of population change, viz., fertility, mortality and migration.
3. Population composition and structure – They include a set of demographic characteristics (such as age-sex structure, marital status and average age at marriage etc.), social characteristics (such as caste, racial/ethnic, religious and linguistic composition of population; literacy and levels of educational attainment etc.), and economic characteristics (such as workforce participation rate and workforce structure etc.)

Population geography receives many important primary data from demography, which reveals the geographic aspects population change. Population geography also uses field teams for observation and investigation. It studies the physical forms of inhabitations (types of residences according to spatial differences, the nature of planning and engineering for populated points, and so on), because all of these features are reflected in the regional characteristics of the physical makeup of cities and rural settlements. The location of the population both throughout the country and within its regions and the territorial organization of the population are basically determined by the nature and geography of production.

The population density of individual populated points is usually related to their national economic functions, and the population density of regions reflects the degree of their economic development. At the same time the established location of population exerts in its turn an influence on the geography of production. The natural environment's influence on settlement occurs primarily through production. It can be seen that the study of population is multidisciplinary in nature, involving an understanding of biology, genetics, mathematics, statistics, economics, sociology, cultural anthropology, psychology, politics, geography, medicine, public health, ecology, etc.

G. T. Trewartha confined the content of population geography as follows:

- a) Distribution
- b) Density of Population
- c) Migration
- d) Growth of Population
- e) Composition of Population
- f) Literacy & Quality of Population
- g) Rural and Urban Population
- h) Technological Development & Population Resources Ratio
- i) A Geographical Overview of World Population

3.0 Sources of Population Data in India

There are different sources of population data in India. These are as follows.

- (i) Census of India – Population enumeration tables,
- (ii) Civil Registration System,
- (iii) Sample Surveys such as National Sample Surveys (NSS) and Sample Registration System (SRS),

(iv) Health Surveys, such as National Family Health Surveys (NFHS),

(v) District Level Household and Facility Surveys (DLHS)

Table 1: Sources and Nature of Population Data

Data	Organisation	Data
Population census	Office of the Registrar General of India	Total Population, Male, Female, Child, Homeless population, Literacy, Economy, Migration, Village profile, Town profile etc.
Civil Registration System	Office of the Registrar General of India	Birth, death and marriage
Sample Registration System	Office of the Registrar General of India	Fertility, mortality, infant mortality rate
National Sample Survey	National Sample Survey Organisation (NSSO)	People's economic profile, food consumption, migration etc.
National Family Health Surveys (NFHS)	Ministry of Health and Family Welfare and International Institute of Population sciences (IIPS)	Fertility, mortality, morbidity, nuptiality, nutrition, child care, breast feeding, family planning, pre and post-natal care etc.
District Level Household and Facility Surveys (DLHS)	Ministry of Health and Family Welfare and International Institute of Population sciences (IIPS)	ASHA, JNRM, JSY

- i) **Population census** – Started in 1870-71, population census is one of the most dependable sources of population data in India. It not only enumerates the total population of the country but also the economic, social, cultural and demographic aspects of people. Population census is carried out in every ten years. The last census has been published in 2011. There are several steps of population enumeration. These are a) preparatory work, b) enumeration, c) data processing, d) building of needed databases and dissemination of the results, e) evaluation of the results and f) analysis of the results.

The earliest literature 'Rig-Veda' reveals that some kind of population count was maintained in during 800-600 BC in India. The celebrated 'Arthashastra' by 'Kautilya' written in the 3rd Century BC prescribed the collection of population statistics as a measure of state policy for taxation. It contained a detailed description of methods of conducting population, economic and agricultural censuses. During the regime of the Mughal king Akbar, the administrative report 'Ain-e-Akbari' included comprehensive data pertaining to population, industry, wealth and many other characteristics.

A systematic and modern population census, in its present form was conducted non-synchronously between 1865 and 1872 in different parts of the country. This effort culminating in 1872 has been popularly labeled as the first population census of India

However, the first synchronous census in India was held in 1881. Since then, censuses have been undertaken uninterruptedly once every ten year.

The Census of India 2001 was the fourteenth census in the continuous series as reckoned from 1872 and the sixth since independence. The gigantic task of census taking was completed in two phases. In the first phase, known as House -listing Operations, all building and structures, residential, partly residential or non- residential were identified and listed and the uses to which they were put recorded. Information on houses, household amenities and assets were also collected. In the second phase, known as Population Enumeration, more detailed information on each individual residing in the country, Indian national or otherwise, during the enumeration period was collected. At the Census 2001, more than 2 million (or 20 lakh) enumerators were deployed to collect the information by visiting every household. The Indian Census is one of the largest administrative exercises undertaken in the world.

- ii) **Civil Registration System (CRS)** – Civil Registration System is a system in which the birth, death and marriage of citizens of a country are registered. Thus it forms a database repository, also known as civil registry. Registration of birth is a basic right of a child and it is the first identity of a new-born baby. The births and deaths are registered at the place of their occurrence. These are the vital statistics of a country.

The history of Civil Registration System (CRS) in India dates back to the middle of the 19th century. In 1886 a Central Births, Deaths and Marriages Registration Act was promulgated to provide for voluntary registration throughout British India.

In the Post-Independence, the Registration of Births and Death Act (RBD Act) was enacted in 1969 to promote uniformity and comparability in the registration of Births and Deaths across the country and compilation of vital statistics based thereon. With the enactment of the Act, registration of births, deaths and still births has become mandatory in India. The Registrar General, India (RGI) at the Central Government level coordinates and unifies the activities of registration throughout the country. However, implementation of the statute is vested with the State Governments. The registration of births and deaths in the country is done by the functionaries appointed by the State Governments. Directorate of Census Operations are the sub-ordinate offices of Office of the Registrar General, India and these offices are responsible of monitoring of working of the Act in their concerned State/UT.

- iii) **Sample Registration System (SRS)** – Started in 1964-65, Sample Registration Survey covers the vital statistics data – data of fertility, mortality and Infant Mortality Rate for a sample area, either rural or urban area. It is done in two phases – baseline survey and continuous enumeration. The SRS data are published almost in every ten years.

Registration of births and deaths is an important source for demographic data for socio-economic development and population control in developing countries. The data on population growth, fertility and mortality serves as the starting point for population projections. Apart from these vital indicators, an adequate evaluation of a number of programs in the health sector, including family planning, maternal and reproductive health, immunization programs, is dependent upon the availability of accurate, up-to-date fertility and mortality data. In India, the need for dependable demographic data was felt soon after independence heralding the era of five year planning.

The registration of births and deaths started on voluntary basis and there was no uniformity in statistical returns resulting in both under-registration and incomplete coverage. In order to unify the civil registration activities, the Registration of Births & Deaths Act, 1969

was enacted. Despite having the registration of birth & death compulsory under the statute, the level of registration of births and deaths under the Act has continued to be far from satisfactory in several states/UTs. With a view to generate reliable and continuous data on these indicators, the Office of the Registrar General, India, initiated the scheme of sample registration of births and deaths in India popularly known as Sample Registration System (SRS) in 1964-65 on a pilot basis and on full scale from 1969-70. The SRS since then has been providing data on regular basis.

- iv) **National Sample Survey (NSS)** – Presently, the Ministry of Statistics and Programme Implementation (MoSPI) publishes the NSS data. This data is collected from sample representative areas – both rural and urban. The National Sample Survey Office (NSSO) headed by a Director General is responsible for conduct of large scale sample surveys in diverse fields on All India basis. Primarily data are collected through nation-wide household surveys on various socio-economic subjects, Annual Survey of Industries (ASI), etc. Besides these surveys, NSSO collects data on rural and urban prices and plays a significant role in the improvement of crop statistics through supervision of the area enumeration and crop estimation surveys of the State agencies. It also maintains a frame of urban area units for use in sample surveys in urban areas

- v) **National Family Health Survey (NFHS)** - The National Family Health Survey (NFHS) was first conducted in 1992-93. Since then it is being conducted several years interval. Till now three rounds of survey results have been published. This survey encompasses issues like fertility, mortality, nuptiality, child health care system, medical facility, immunization policy, infant mortality, maternity, reproduction, family planning, women's reproductive health, nutrition, metabolism etc. The Ministry of Health and Family Welfare (MoHFW) has deputed International Institute of Population Sciences (IIPS) as the nodal agency to conduct the survey.

The National Family Health Survey (NFHS) is a large-scale, multi-round survey conducted in a representative sample of households throughout India. Three rounds of the survey have been conducted since the first survey in 1992-93. The survey provides state and national information for India on fertility, infant and child mortality, the practice of family planning, maternal and child health, reproductive health, nutrition, anaemia, utilization and quality of health and family planning services. Each successive round of the NFHS has had two specific goals: a) to provide essential data on health and family welfare needed by the Ministry of Health and Family Welfare and other agencies for policy and programme purposes, and b) to provide information on important emerging health and family welfare issues. The Ministry of Health and Family Welfare (MOHFW), Government of India, designated the International Institute for Population Sciences (IIPS) Mumbai, as the nodal agency, responsible for providing coordination and technical guidance for the survey. IIPS collaborated with a number of Field Organizations (FO) for survey implementation. Each FO was responsible for conducting survey activities in one or more states covered by the NFHS.

- vi) **District Level Household and Facility Survey (DLHS)** – The District Level Household and Facility Survey enumerates the antenatal care and immunization services, unmet need for family planning, proportion of institutional and safe deliveries, the role of Accredited Social Health Activist (ASHA), the process of National Rural Health Mission (NRHM), success of Janani Suraksha Yojana (JSY) etc. The first DLHS was carried out in 1998-99.

The Ministry of Health and Family Welfare (MoHFW), Government of India has designated the International Institute for Population Sciences (IIPS), Mumbai as the nodal

agency for conducting the District Level Household and facility Survey (DLHS). It is a household survey at the district level and in DLHS-3, the survey covered 611 districts in India. The total number of households representing a district varies from 1000 to 1500 households. The DLHS-3 is designed to provide information on family planning, maternal and child health, reproductive health of ever married women and adolescent girls, utilization of maternal and child healthcare services at the district level for India. In addition, DLHS-3 also provides information on new-born care, post-natal care within 48 hours, role of ASHA in enhancing the reproductive and child health care and coverage of Janani Suraksha Yojana (JSY). An important component of DLHS-3 is the integration of Facility Survey of health institution (Sub centre, Primary Health Centre, Community Health Centre and District Hospital) accessible to the sampled villages. The focus of DLHS-3 is to provide health care and utilization indicators at the district level for the enhancement of the activities under National Rural Health Mission (NRHM).



Plate 1: Census Enumeration in India
Source: The Hans India

4.0 Distinction of Population Geography from Demography

Population geography involves demography in a geographical perspective. It deals with geographical distribution of population and geographical variation in population in relation to indicators including demographic parameters. Thus it includes a number of environmental determinants also. Demography, on the other hand, is the study of population change in relation to fertility, mortality and migration. Thus, demography involves statistical analysis and explanation of crude birth rate, crude death rates, morbidity etc. of a country. Population geographers often focus on different population groups of different geographical regions while demographers study population of a country, state or locality.

Demography is the empirical, statistical, and mathematical study of human populations. It focus on change in population size (growth or decline), composition of the population, and the distribution of population in space. According to G. T .Trewartha, “Population geography studies the characteristics of various human groups, found in different geographical regions”.

5.0 Theories of Population Growth

Though the history of vague thinking on population-resource nexus dates back to the days of Plato, yet Thomas Robert Malthus was the first person to systematize information on this matter and initiate a number of views expressed in his first essay which later came to be known as Malthusian Principle

of Population. Since then, a number of scholars have attempted to search for some laws governing the population growth. A distinction has been made between natural law based population theories and social theories of population. Besides Malthus, other scientists proposing natural law based theories are Michael Thomas Sadler, Thomas Doubleday, Herbert Spencer etc. The social theorists, on the other hand, are Henry George, Arsene Dumont, David Ricardo and Karl Marx.

A) Natural-Law based population Theories

5.1 Malthusian Theory of population Growth

Malthus was an English clergyman who thought deeply about economic problems and is best known for his Essay on the Principle of Population. Malthus wrote his first version of the Essay in 1798, but for the so-called second edition (1803), he revised the work so extensively that it is really a new book.

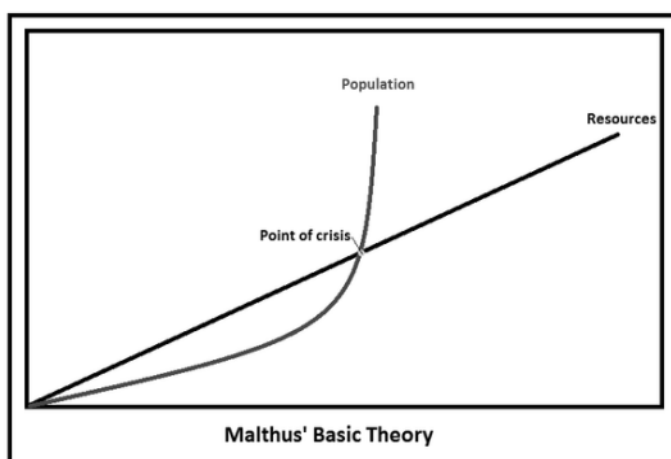
The Malthusian theory explains the relationship between the growth in food supply and in population. It states that population increases faster than food supply, and if unchecked leads to vice or misery. The Malthusian doctrine is stated as follows:

(1) There is a natural sex instinct in human beings to increase at a fast rate. As a result, population increases in geometrical progression and if unchecked doubles itself every 25 years. Thus starting from 1, population in successive periods of 25 years will be 1, 2, 4, 8, 16, 32, 64, 128, and 256 (after 200 years).

(2) On the other hand, the food supply increases in a slow arithmetical progression due to the operation of the law of diminishing returns based on the supposition that the supply of land is constant. Thus the food supply in successive similar periods will be 1, 2, 3, 4, 5, 6, 7, 8, 9 (after 200 years).

(3) Since population increases in geometrical progression and the food supply in arithmetical progression, population tends to outrun food supply. Thus an imbalance is created which leads to over-population.

The food supply in arithmetical progression is measured on the horizontal axis and the population in geometrical progression on the vertical axis. The curve M is the Malthusian population



curve which shows the relation between population growth and increase in food supply. It rises upward swiftly.

(4) To control over-population resulting from the imbalance between population and food supply, Malthus suggested preventive checks and positive checks.

The preventive checks are applied by a man to control the birth rate. They are foresight, late marriage, celibacy, moral restraint, etc.

If people fail to check growth of population by the adoption of preventive checks, positive checks operate in the form of vice, misery, famine, war, disease, pestilence, floods and other natural calamities which tend to reduce population and thereby bring a balance with food supply. According to Malthus, preventive checks are always in operation in a civilized society, for positive checks are crude. Malthus appealed to his countrymen to adopt preventive checks in order to avoid vice or misery resulting from the positive checks. Malthus' doctrine is illustrated below.

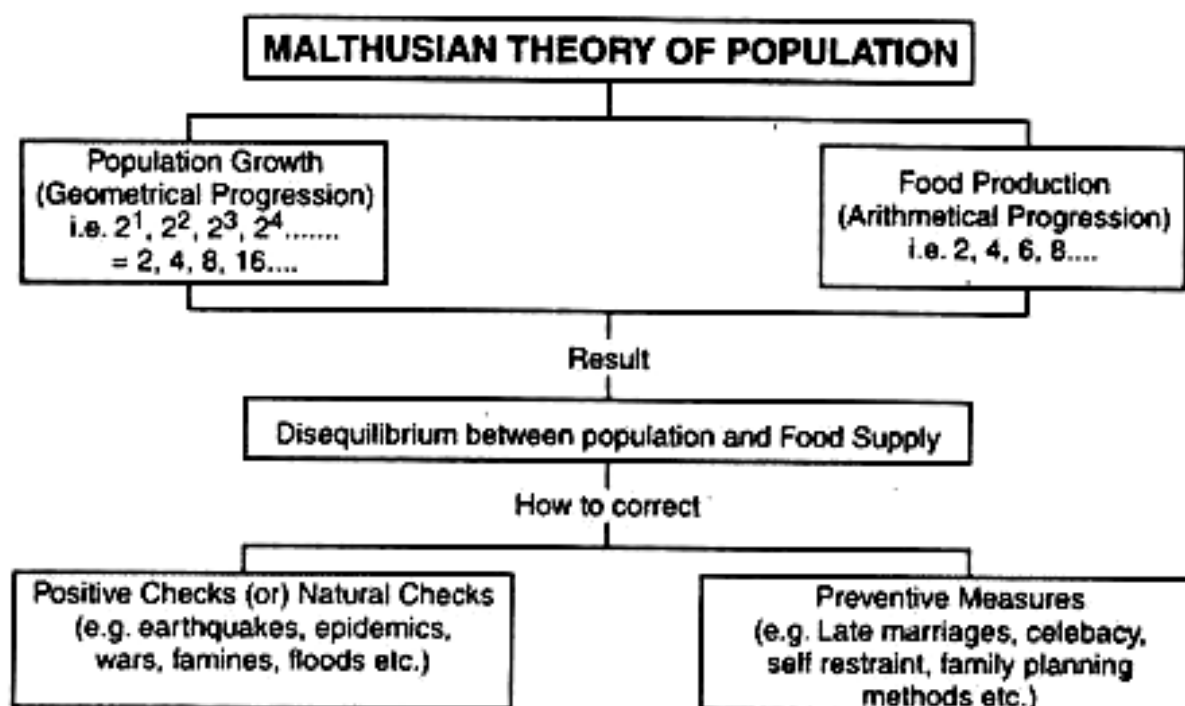


Figure 2: Summary of the Malthusian Theory

5.1.1 Criticisms of the Malthusian Doctrine:

The Malthusian theory of population has been widely discussed and criticized during the 19th and early 20th century. Some of the criticisms are as follows:

(i) Mathematical Form of the Theory Wrong

The mathematical formulation of Malthus' doctrine that food supply increases in arithmetical progression and population increases in geometrical progression in 25 years has not been proved empirically. Rather, the food supply has increased more than in the arithmetical progression while population growth has not been in geometrical progression so as to double the population in 25 years. But this criticism is beside the point because Malthus used his mathematical formulation to make his principle clear in the first edition of his Essay and deleted it in its second edition.

(ii) Failed to foresee the Opening up of New Areas

Malthus had a narrow vision and was particularly influenced by local conditions in England. He failed to foresee the opening up of new areas of Australia, the United States and Argentina where extensive farming of virgin lands led to increased production of food. As a result, countries like England on the

continent of Europe have been provided with abundant supplies of cheap food. This has been made possible with rapid improvements in the means of transport, a factor almost overlooked by Malthus. No country need fear starvation and misery if it does not produce sufficient for its increasing population these days.

(iii) Applied a Static Economic Law to a Period of Time

The Malthusian notion that the food supply increases in arithmetical progression is based on a static economic law at any one time i.e., the law of diminishing returns. Malthus could not foresee the unprecedented increase in scientific knowledge and agricultural inventions over a period of time which has stayed the law of diminishing returns. Consequently, the food supply has increased much faster than in arithmetical progression. Malthus has been proved wrong not only in the advanced countries but also in developing countries like India with the 'green revolution'.

(iv) Neglected the Manpower Aspect in Population

One of the principal weaknesses of Malthus' thought has been that he neglected the manpower aspect in population growth. He was a pessimist and dreaded every increase in population. He forgot, according to Cannan, that "a baby comes to the world not only with a mouth and a stomach, but also with a pair of hands." This implies that an increase in population means an increase in manpower which may tend to increase not only agricultural but also industrial production and thus makes the country rich by an equitable distribution of wealth and income. As rightly pointed out by Seligman, "The problem of population is not merely one of mere size but of efficient production and equitable distribution." Thus the increase in population may be necessary.

(v) Population not related to Food Supply but to Total Wealth

The Malthusian theory rests on a weak relationship between population and food supply. In fact, the right relationship is between population and total wealth of the country. This is the basis of the optimum theory of population. The argument is that if a country is rich materially and even if it does not produce enough food for its population, it can feed the people well by importing food stuffs in exchange for its products or money.

The classic example is of Great Britain which imports almost all its food requirements from Holland, Denmark, Belgium and Argentina because it concentrates more on the production of wealth rather than on food products. Thus the very basis of the Malthusian doctrine has been proved wrong.

(vi) Increase in Population: The Result of Declining Death Rate

The Malthusian theory is one sided. It takes the increase in population as the result of a rising birth rate, whereas population has grown considerably the world over due to a decline in death rate. Malthus could not foresee the marvelous advancements in the field of medical sciences which have controlled fatal diseases and made human life longer. This has been particularly so in underdeveloped countries like India where the Malthusian theory is said to operate.

(vii) Empirical Evidence proves this Theory Wrong

Empirically, it has been proved by demographers that population growth is a function of the level of per capita income. When per capita income increases rapidly, it lowers the fertility rate and the rate of population growth declines. Dumont's "social capillarity thesis" has proved that with the increase in

per capita incomes, the desire to have more children to supplement parental incomes declines. When people are accustomed to a high standard of living, it becomes a costly affair to rear a large family. Population tends to become stationary because people refuse to lower their standard of living. This has actually happened in the case of Japan, France and other western countries.

(viii) Preventive Checks do not pertain to Moral Restraint

Malthus was essentially a religious man who laid emphasis on moral restraint, celibacy, late marriage, etc. to control population. But he could not visualize that human beings would invent contraceptives and other family planning devices for birth control. This was perhaps due to the fact that he could not make any distinction between sexual desire and the desire to have children. People have sexual desire but they do not want to have more children. Thus moral restraint alone cannot help to control the increase in population which Malthus suggested. Family Planning is essential as a preventive check.

(ix) Positive Checks not due to Over-population

Malthus' pessimism and religious education led him to believe that over-population was a heavy burden on the earth which was automatically lessened by God in the form of misery, wars, famines, floods, diseases, pestilence, etc. But all these are natural calamities which are not peculiar to over-populated countries. They visit even those countries where the population is on the decline or stationary, such as France and Japan.

(x) Malthus a False Prophet

The Malthusian theory is not applicable to countries for which this was propounded. In the western European countries, the bogey and pessimism of Malthus has been overcome. His prophecy that misery will stalk these countries if they fail to check the growth of population through preventive checks has been proved wrong by a decline in birth rate, adequacy of food supply, and increase in agricultural and industrial production. Thus Malthus has proved to be a false prophet.

5.1.2 Its Applicability

Despite these weaknesses, the Malthusian doctrine contains much truth. The Malthusian doctrine may not be applicable to the Western Europe and England but its principal tools have become the part and parcel of the people of these countries. If these lands do not face the problems of over-population and misery, it is all due to the bogey and pessimism of Malthusianism.

In fact, the people of Europe were made wiser by Malthus who forewarned them of the evils of over-population and they started adopting measures toward it off. The very fact that people use preventive checks, like late marriage and various contraceptives and birth control measures on an extensive scale proves the vitality of the Malthusian law.

Even famous economists like Marshall and Pigou and sociologists like Darwin were influenced by this principle when they incorporated it in their theories. And Keynes, initially overawed by the Malthusian fears of over-population, later wrote about "Some Economic Consequences of Declining Population." Is it not the fear of Malthusianism which has created the problem of declining population in France?

The Malthusian doctrine may not be applicable now to its place of origin, but its influence spreads over two-third of this universe. Excluding Japan, the whole of Asia, Africa and South

America come under its purview. India is one of the first countries to adopt family planning on state level to control population. Positive checks like floods, wars, droughts, disuses, etc. operate.

The birth and death rates are high. The growth rate of population is about two per cent per annum. The real aim of population policy is, however, not to avoid starvation but to eliminate poverty so as to raise output per head in an accelerated manner. Thus the Malthusian theory is fully applicable to underdeveloped countries like India. Walker was right when he wrote: "The Malthusian theory is applicable to all communities without any consideration of colour and place. Malthusianism has stood unshattered, impregnable amid all the controversy that has raged around it."

5.2 Law of Population by Michael Thomas Sadler

M. T. Sadler (1780-1835), a contemporary of Malthus was also British economist and social reformer. According to him, the natural law of population growth was exactly opposite of that grounded by Thomas Robert Malthus. He found an inverse relation between human being's tendency to increase their numbers and the existing density of population of an area. According to him, human being's tendency to increase in numbers would diminish as the density of population in the territory increased. All other things being equal, the population numbers would cease to grow beyond a point where it had secured the utmost degree of happiness for the largest possible number of human beings.

5.3 Thomas Doubleday's Theory of Natural Population Growth (1790-1870)

A British economist and social reformer, Doubleday held that increase in human population was inversely related to the food supply. This meant that places where there was better food supply would show slow increase in population.

A constant population increase can be seen in places with worst food supplies, that is, the poorest people. Between the two extremes are areas with tolerably good food supplies and here the population is stationary.

It was on the basis of Doubleday's law that Castro later (1952) said that higher protein intake reduces the fecundity of a population and low protein intake increases it. However, Thompson and Lewis (1976) have pointed out there is no scientific basis for believing that factors like population density, proportion of protein intake and the relative abundance of calorie intake have a Substantial and noticeable effect on fecundity.

5.4 Herbert Spencer (1820-1903)

A British philosopher, Spencer tried to explain the role of natural forces in social and biological developments. His theory of population, similar to those of Sadler and Doubleday, believed in a natural law that absolved humans from any responsibility for the control of population.

The Nature would weaken humans' interest in reproduction and make them devote more time for personal, scientific and economic development. For, the reproductive interest and capacity of individuals shall decline with their personal advancement as the latter would claim more of their time and energy. The decline in fecundity ensured a slow rate of population growth.

B) Social Theories

The difficulty of finding conclusive evidence about the existence of natural law controlling humans' fecundity gave a boost to social theories on population growth.

5.5 Henry George (1839-1897)

An American economist and social reformer, Henry George tackled the principle of basic antagonism between the human tendency towards population increase and the human ability to provide subsistence for the increased number of people. He held the view that unlike the case of other living beings, an increase in the human population involved increase in his food as well. The threat to existence of humans is not from the ordinances of nature but from social maladjustments.

5.6 Arsene Dumont (1849-1902)

Stressed upon social capillarity—the tendency among people to reach higher levels socially. This tendency prevents rapid reproduction by man. Humans are then more concerned about upward mobility for personal benefit than about the welfare of the growth rate. This is because they believe the development of numbers in a country or society is in an inverse ratio to development of individuals. As his study was based on study of population growth in France, he pointed out that in France, the birth rates declined with the establishment of democracy and weakening of hurdles in the way of upward mobility.

In societies that are rigidly structured, mainly those in developing and under-developed countries, the social capillarity is largely inactive. However, growth of big cities in these countries has resulted in the social capillarity prevailing in the hinterlands of the cities. Here the birth rate may decline. But in areas where individual ambition does not develop much, high birth rates continue.

According to Dumont, the actual conditions under which people live are very important as the preventive checks of population growth depend upon these conditions (for instance, delayed marriages and use of contraception on an increased scale in much urbanised areas where there is greater stress on individuality).

5.7 David Ricardo (1772-1823)

The analytical approach of Ricardo resulted in his building up of a normative model of market system. He expanded on the labour-wage link and the impact of capital accumulation on population. Ricardo held that increased demand for labour resulted in increased wages but with increase in supply of labour, there would be a fall in wages. Ultimately, the wages shall settle at a natural wage governed by cost of subsistence.

The wage level was dependent on labour supply, which in turn was dependent on population growth, as well as capital accumulation. Population, he believed, regulated itself based on the availability of funds to employ it. So it would increase or decrease based on increase or decrease of the rate of capital accumulation.

Ultimately such an arrangement would result in a state where the demand and supply of labour shall be equated and then the capital accumulation would stop. As per the law of diminishing returns, then, there would be universal poverty as all would receive only subsistence wage. According to Ricardo, misery and poverty are inevitable in the natural circumstance.

6.0 Factors Controlling Fertility, Mortality and Migration

Fertility is a way through which human beings biologically replace themselves in order to continue their existence on earth. The study of human fertility is of paramount importance in population

studies. Human fertility is responsible for the biological replacement and maintenance of the human species, since every society replenishes itself and grows through the process of fertility. Studies have reported that there are plethoras of factors that affect the fertility pattern of a population, either directly or indirectly.

6.1 Factors Controlling Fertility

A) Social Factors

- Preference for a male child
- Women's status in the society
- Age at Marriage
- Social Norms
- Use of Contraceptive Measures
- Family Planning

B) Economic Factors

- Occupational Distribution
- Women's Employment
- Per Capita Income
- Child Work Participation

C) Cultural Factors

- Exposure to mass-media
- Religious and Ethnic Identity

A) Social Factors

Among the social factors that affect the fertility status of a population, **preference for male**

child is one of the most important. The preference for a male child among the parents in the Indian society is one of the most important reasons leading to the explosion of population. Among the social attitudes that have a bearing on fertility, directly or indirectly, is the **status accorded to women** in the society. In Indian societies, the women were assigned a submissive and secondary role and it was thought that women do not deserve independence. Women's status is singled out as the most determining factor in controlling the fertility pattern of a country. Some societies limit girls' access to formal education, thereby limiting future employment and economic freedom. Girls' education often ends with an early marriage. It is found that in countries such as USA, Sweden etc. where women's education is high, fertility is low. On the other hand, in countries such as Afghanistan, Niger where women are less educated, fertility rate is high (Fig. 3).

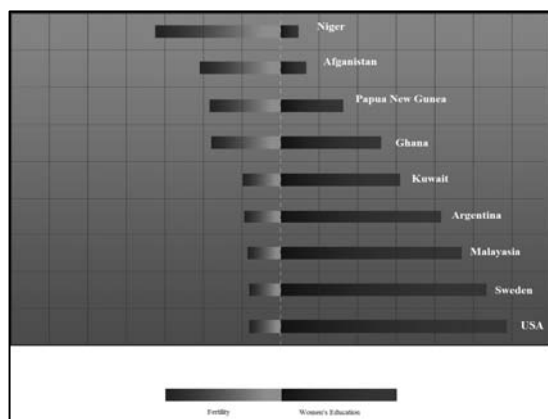


Figure 3: Relation between Women's Education and Fertility of Few Countries

Source: Barro-Lee Educational Attainment Datasheet (2015)

the other hand, in countries such as Afghanistan, Niger where women are less educated, fertility rate is high (Fig. 3).

Marriage is universal in most of the societies, but its type and the custom vary depending upon the religious and other cultural practices of the communities. **Age at marriage** is influenced by the socioeconomic condition. It is usually low among the women who belong to the lower socioeconomic status. It is assumed that longer the duration of reproductive span, higher is the number of children. Therefore, lower the age at marriage, higher is the fertility.

The differences in **social norms** are of profound influences in Indian societies determining the fertility pattern in the country. Reproduction is not only a biological factor but also a social matter. It is guided by different social institutions including the family. The social norms are often influenced by religious factors. In places where the social norms are very rigid, fertility rate is generally higher.

Too many births too close together, or at too young or too old an age, are a major cause of illness, disability, poor nutrition and premature death among women and children. Fewer births can significantly improve the lives of women and children's survival, nutrition, health and education. A significant proportion of these deaths and under-nutrition can be avoided using the **family planning methods**. The total fertility rate (TFR) is around six to seven births per woman in countries with no contraceptive use, while fertility is near two births per woman in countries in which the contraceptive prevalence rate (CPR) among women is around 75 per cent. This inverse relationship has been repeatedly documented using cross-sectional data from a large number of countries (Bongaarts, 2017).

B) Economic Factors

Reproductive factor is often found to be sensitive to the geographical and economic factors. Exposure to putative hazardous substances in environmental and **occupational settings** lowers down the fertile rate.

Over the last few decades, one of the most important demographic changes has been the constant increase in **female labour force participation**, which has been a generalized tendency around the world. The changing role of women has produced several transformations of the family structure. Their increased propensity to enter the labour force, and thus increased independence, imply changes in childbearing practices.

There is a negative relation between **per capita income** and fertility. The decreasing relationship between the two variables demonstrates the connection between fertility choices and economic considerations. In general, poor countries tend to have higher levels of fertility than rich countries. This decreasing relationship between fertility and income is well known to economists and demographers alike. In addition, it holds true over time: Rich countries, such as the U.S., have experienced a remarkable decline in their fertility rate as they became rich. Also, the relationship holds at the individual level, as rich families tend to have fewer children than poor families.

C) Cultural Factors

There is a long tradition of addressing **religious affiliation** as a determinant of demographic behaviour. Particularly, the interest has long been focused on fertility differentials by religious denomination. Some religions promote large families. Emphasis on the importance of family and a positive evaluation of large families may favour higher fertility. It also leads to thinking that the practice of family limitation is contrary to their religious belief. In India, Muslims have highest fertility rate (2.61 per woman). Muslim women are less receptive to family planning than Hindu women. Besides, Islamic beliefs, in contrast to Hindu beliefs, support polygamy, allow for easy divorce in case of infertility, and allow widows to remarry.

Religion	TOTAL FERTILITY RATE		Decline
	NFHS-4 (2015-16)	NFHS-3 (2005-06)	
Hindu	2.13	2.59	0.46
Muslim	2.61	3.40	0.79
Christian	1.99	2.34	0.35
Sikh	1.58	1.95	0.37
Buddhist/ Neo-Buddhist	1.74	2.25	0.51
Jain	1.20	1.54	0.34
Other	2.57	3.98	1.41

Figure 4: Religion and Fertility Rate

Media exposure increases the different family planning methods, government's decision about family size and also to different schemes proposed for the development of pregnant women and for mothers. Exposure to general media programming and to family planning messages through the media has a strong impact on reproductive attitudes and behaviours in the developing countries. Mass media may be influential in the diffusion of attitudes and knowledge about family planning along with the change in world views or value systems which indirectly affect fertility or social behaviour.

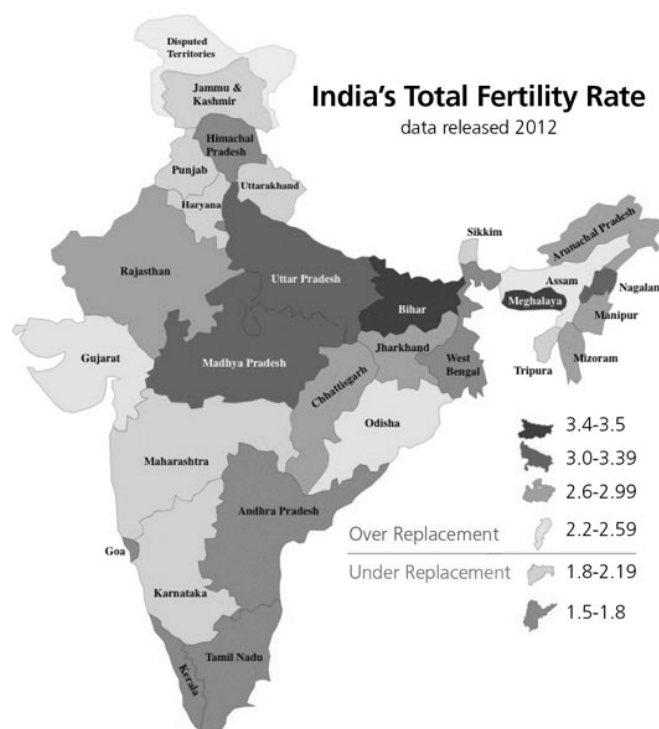
6.1.1 Fertility Trends in India

Fertility in India has declined substantially, from a total fertility rate (TFR) of 5.7 children per woman in the mid-1960 to 3.3 children in 1997. Since the mid-1960's, India has covered two-thirds of the distance to the replacement fertility of just over two births per woman. Fertility varies widely among States; it is significantly below the national average in the southern and western States and higher in the others. With a TFR of 5.2 in 1993, Uttar Pradesh clearly stands out as having especially high fertility, nearly 50 per cent above the national level.

Contraceptive Prevalence The national family planning program, which was established in 1952, has played an important role in India's fertility decline. When the program began, there was little awareness or use of modern birth control methods. Four decades later, the 1992-93 National Family Health Survey (NFHS) found nearly universal knowledge of family planning, with 96 per cent of married women ages 13 to 49 years having heard of at least one modern method, and almost 41 per cent, or almost 70 million women, using contraception. Eighty-nine per cent of married women who practiced family planning in India relied upon modern contraceptive methods. Female sterilization, the method which is strongly promoted by India's family planning program, was by far the most widely used method.

Nearly 67 per cent of married women who were using contraception, or 47 million women, had been sterilized compared with an average of only 30 per cent for the entire world. Spacing methods, primarily available through the private sector, were used by a small proportion of users: the pill by 3 per cent, IUD by 5 per cent, and condom by 6 per cent. Education, religion, place and State of residence are among the factors that strongly correlate with contraceptive use in India (figure 5). Nearly half of the married women with some primary schooling use contraception compared with one third of illiterate women. Differentials by religion are also strong. Higher prevalence rates (48 to 63 per cent) are found among small minority religions (Jains, Sikhs, Buddhists, and Christians) than among Hindus (42 per cent), and the lowest use (28 per cent) is

found among Muslims. A higher proportion of urban married women (51 per cent) than rural married women (37 per cent) use contraceptives.



Fertility Preference and Unmet Need for Family Planning

According to the NFHS, a large majority of married women in India (77 per cent) prefer to regulate their fertility: 26 per cent do not want another child, 31 per cent (or their husbands) were sterilized, and 20 per cent want to postpone their next birth. However, the survey found incongruence between women's desire and actual practice to regulate their fertility. Nearly 23 per cent of births during the 4-year period before the survey were not wanted by women: 14 per cent of all births were mistimed and 9 per cent were not wanted at all. If there were no unwanted births in India, its TFR would be lower by nearly three quarters of a child. For Uttar Pradesh, avoidance of unwanted births could reduce the TFR by at least one child. A substantial portion of the total demand for family planning services remains unsatisfied. According to the NFHS, nearly 20 per cent of married women in India have an unmet need for family planning: 8.5 per cent want to stop having children and 11.0 per cent want to postpone their next birth. Unmet need for spacing is a substantial portion of the total unmet need for family planning—most of the unmet need among younger women is for spacing. This suggests that more attention should be given to methods other than sterilization, such as condom, the pill, and IUD.

Further, fully meeting today's unmet need for family planning, that is, providing services to an additional 35 million women, will require substantial additional resources. If this were accomplished, India could meet its goal for 2016 of having 60 per cent of married women practicing family planning. To meet this goal in 2016, will require that 159 million women practice family planning (about double the current number). Unmet need for family planning also varies by States. In most southern and western States, where the family planning program is considered to be more effective, unmet need is 15 per cent or less. In contrast, 30 per cent of women in Uttar Pradesh, or 8 million, have unmet need for family planning.



Literacy

Literacy and education, especially of females, affect fertility through greater access and practice of contraception and desire for smaller family size. Literacy in India has improved steadily. The adult literacy rate (ages 15 and over) has risen from 34 per cent in 1971 to 52 per cent in 1995. Although female literacy in India has improved at a faster rate than that of men, in 1995 women continued to have a much lower rate (38 per cent) than men (66 per cent) (UNESCO, 1995). Efforts continue to improve schooling and literacy, especially for girls and women. Many States have begun “total literacy campaigns” to eliminate illiteracy among the disadvantaged population ages 15 to 34 (Visaria and Visaria, 1995).



Figure 7: Declining Fertility Rates, India

6.2 Factors Controlling Mortality

- Mother's Age at Birth
- Birth Interval
- Lack of Breast-feeding
- Gross Domestic Product Per Capita
- Under nutrition
- Suffering from chronic disease
- Immunization Process
- Health Expenditure
- Morbidity
- Toilet Facilities
- Female Illiteracy
- Female Participation in the Labour Force
- Per Capita GNP
- Dependency Ratio

Mother's age has been suspected of being an important factor in determining child's health. Women of early menarche and marriage will have higher rates of prenatal as well as postnatal mortality. The net survivorship of offspring is also related to the onset of menarche as well as age at marriage. The first-born children of adolescent mothers are the most vulnerable to infant mortality and poor child health outcomes. The death of a child is often followed by a shorter interval to the next birth, which may be explained either by volitional replacement or by the fact that the mother stops breastfeeding, enabling her to conceive the next child sooner than otherwise. A short birth interval, in turn, increases the mortality risk of the next child in the family, possibly because the mother has not recuperated from the previous birth. Many a times, this also causes the death of the mother. Thus vulnerable families are caught in a death trap, creating persistence in death risk within families. Delaying the age at first birth may be a valuable strategy to promote and improve neonatal health and survival.

A **birth interval** is only observed if the mother has another birth, and this fertility decision is also influenced by whether her previous birth survived or not. The gender of the last-born child is also significant here. If the last birth was a girl, very often there is expectation for a son-child. Closer the birth interval, children suffer more from under-nutrition and child death is very common. It is also very dangerous for the mother herself. Early weaning is associated with short intervals and poses a threat to the survival index of the child, and may thus give rise to a spurious relationship between spacing and mortality.

According to WHO, **breastfeeding** reduces child mortality and has health benefits that extend into adulthood. Breast-milk promotes sensory and cognitive development, and protects the infant against infectious and chronic diseases. Exclusive breastfeeding reduces infant mortality due to common childhood illnesses such as diarrhoea or pneumonia, and helps for a quicker recovery during illness. Lack of the practice of breastfeeding is thus a factor of poor health, low immunization and of early death.

There is a long-term relationship between growing **GDP per capita** and declining mortality rates. The Millennium Development Goal 2014 shows that one-third of the world's 1.2 billion extremely poor live in India alone. This report also shows that this kind of extreme poverty is one of the reasons of high maternal death, infant mortality rate etc. It causes under-nutrition, lack of access to sanitary infrastructures and a number of diseases such as tuberculosis, pneumonia, rickets, beriberi etc. Some 2.4 million Indians die of treatable conditions every year. Poor care quality leads to more deaths than insufficient access to healthcare.

According to FAO estimates in ‘The State of Food Security and Nutrition in the World, 2018’ report, 14.8 per cent of the population is **undernourished** in India. Also, 51.4 per cent of women in reproductive age between 15 to 49 years are anaemic. Further according to the report 38.4 per cent of the children aged under-five in India are stunted (too short for their age), while 21 per cent suffer from wasting, meaning their weight is too low for their height. Malnourished children have a higher risk of death from common childhood illnesses such as diarrhea, pneumonia, and malaria. The Global Hunger Index 2017 ranks India at 100 out of 119 countries on the basis of three leading indicators -- prevalence of wasting and stunting in children under 5 years, under 5 child mortality rate, and the proportion of undernourished in the population.

Individuals suffering from **chronic diseases** have high mortality risk. According to a report published by WHO in 2001, 60 per cent of the 56.5 million death occurring in the world is due to chronic diseases. These chronic diseases include obesity, hypertension, thyroid, diabetes type II, cardiovascular diseases, rheumatoid arthritis, cancer, liver disease, problems of kidney etc. The proportion of patients suffering from chronic diseases is increasing rapidly throughout the world. These reduce the life expectancy of patients.

Vaccination is a proven and one of the most cost-effective child survival interventions. All countries in the world have an **immunization programme** to deliver selected vaccines to the targeted beneficiaries, specially focusing on pregnant women, infants and children, who are at a high risk of diseases preventable by vaccines. There are at least 27 causative agents against which vaccines are available and many more agents are targeted for development of vaccines. The number of antigens in the immunization programmes varies from country to country; however, there are a few selected antigens against diphtheria, pertussis, tetanus, poliomyelitis, measles, hepatitis B which are part of immunization programmes in most of the countries in the world (Lahariya, 2014). By early 1970s, many childhood diseases had almost disappeared from developed countries. These diseases, however, continued to take many lives in poorer countries. Presently the immunization process has been a major contributor in the decline of under-5 mortality rate from 233 to 63 (per 1000) in last five decades in India.

India spends 1.02 per cent of its total GDP. It roughly stands Rs. 3 per day per every citizen. In India, most of the health care processes are managed by private organisations. Most of the health expenses are born by the patient’s family.

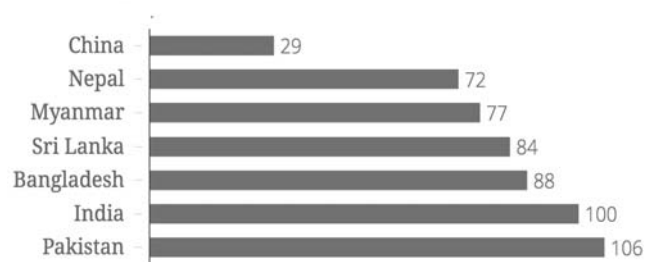
Some 8,42,000 people in low and middle-income countries die as a result of inadequate water, **sanitation**, and hygiene each year, representing 58% of total diarrhoeal deaths. Poor sanitation is believed to be the main cause in some 280,000 of these deaths. Diarrhoea remains a major killer but is largely preventable. Better water, sanitation, and hygiene could prevent the deaths of 361,000 children aged under 5 years each year. Open defecation perpetuates a vicious cycle of disease and poverty. The countries where open defecation is most widespread have the highest number of deaths of children aged less than 5 years as well as the highest levels of malnutrition and poverty, and big disparities of wealth.

In almost every country in the world, men are more likely to **participate in labour** markets than women. However, these gender differences in participation rates have been narrowing substantially in recent decades. Women’s increased earning capacity has a positive effect on child nutrition and health. Their greater exposure increases better child care. Thus, the eventual

outcome of female labour force participation on child mortality depends on the relative strength of these two courses of causation.



Global Hunger Index 2017 Rank



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Data: Global Hunger Index, 2017

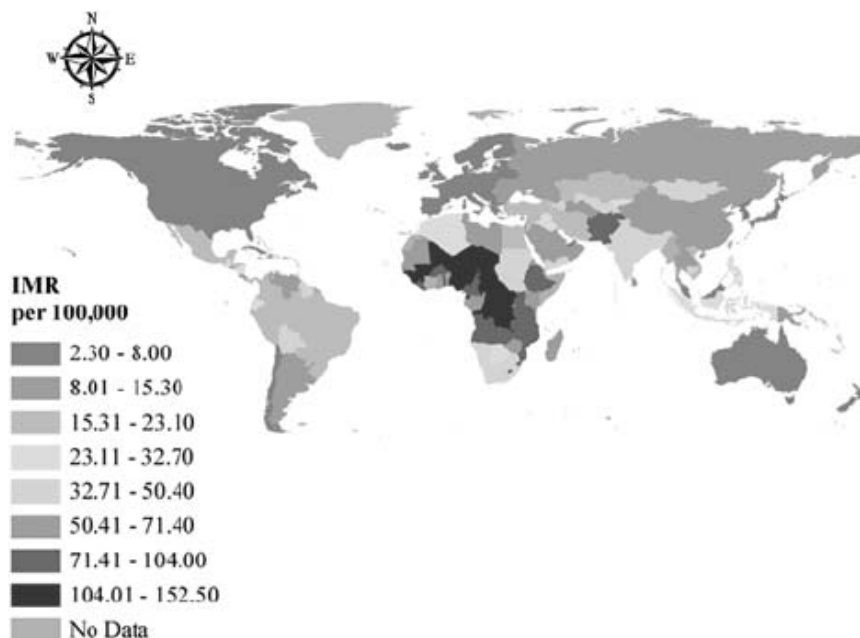
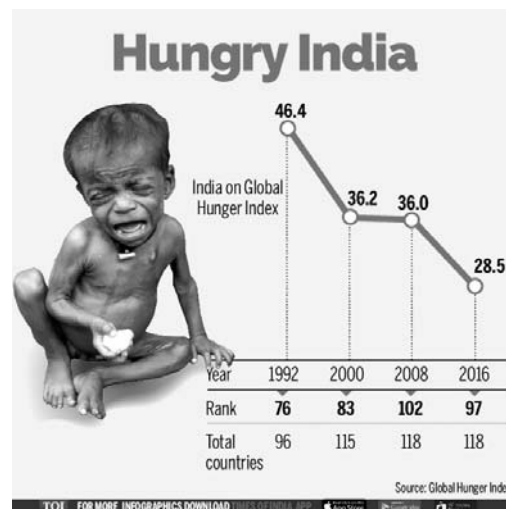


Figure 10: Infant Mortality Rate

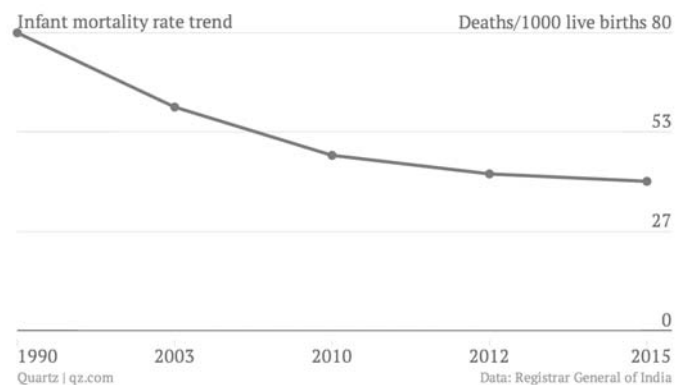
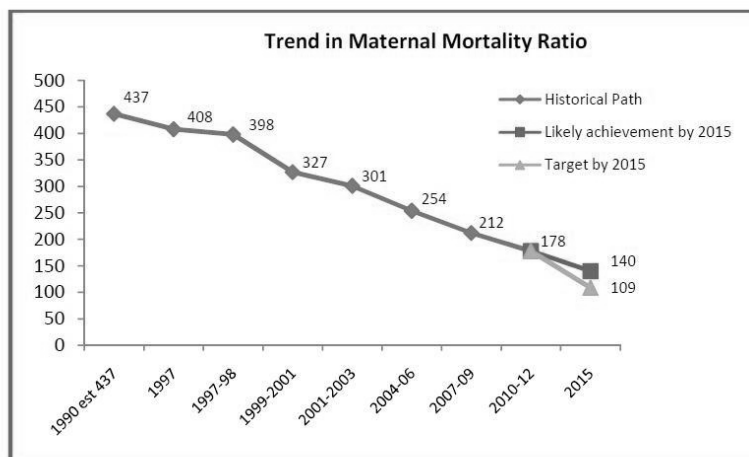
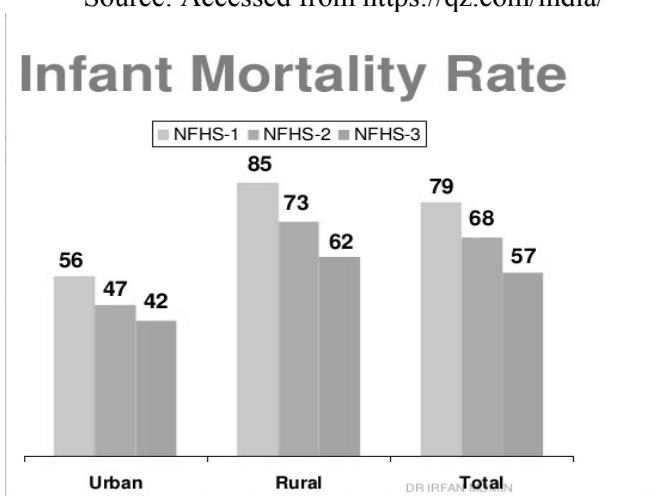


Figure 11: Trends of Infant Mortality Rate in India, 1990 - 2015
Source: Accessed from <https://qz.com/india/>



Source: Sample Registration System, Office of Registrar General of India

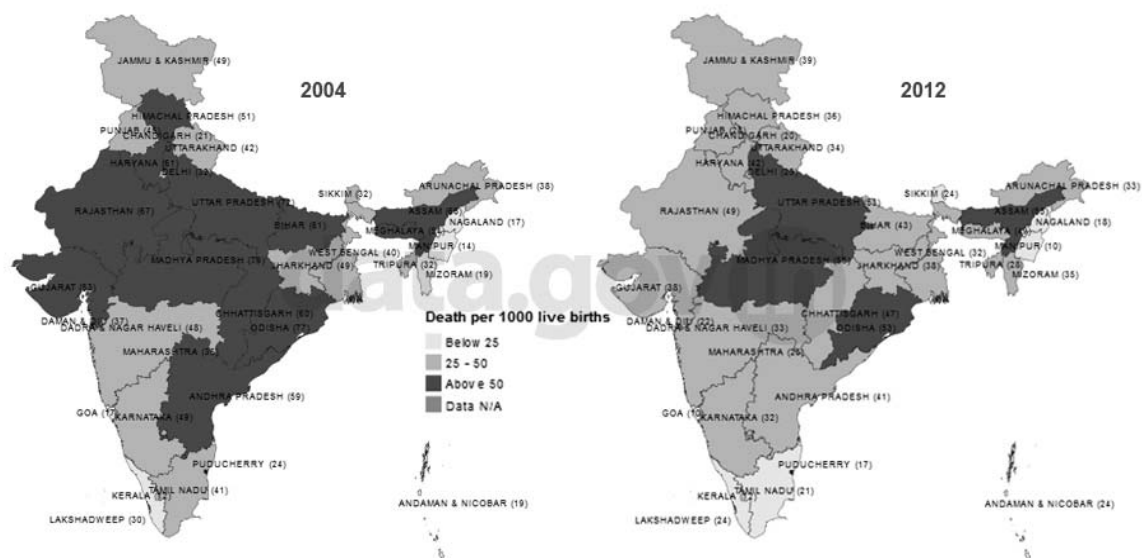


Figure 14: Change in Infant Mortality Rates in India

6.3 Factors Controlling Migration

Different scholars have tried to define the concept of migration distinctly because of their different approaches. While geographers have emphasized on the time and space significance of mobility, sociologists have laid stress on social consequences of mobility whereas importance to economic aspect of migration has been given by the economists. Literal meaning of “Migration” is “shifting of people or an individual or group of individuals from one cultural area to another, which may be permanent or temporary”. In Webster’s dictionary, the term has been defined as “the act or an instance of moving from one country, region to settle in another”. Secondly it is defined as “an act of moving from one area to another in search of work”. According to many individuals, the simplest meaning of the word migration can be a simple shift in the physical space. But it would be interesting to note that meaning of migration is changing simultaneously with the passage of time. Now-a-days, both the scope and definition of migration have become more complicated i.e. only mobility in physical state cannot define the concept of migration.

Smith, T.L (1960), based his concept of migration on change in physical space. The definition suggested by Lee, E.S (1969) in “A Theory of Migration” poses some problems when we look at various types of cyclical migration i.e. the movement of people from villages to urban areas for the duration of their active life, their visits back to the home town for a few days or a month could not be included unless these are for last time at retirement etc. according to Theodore Laplow, “Migration is strictly speaking, a change of residence and it need not necessarily involve any change of occupation, but it is closely associated with occupational shifts of one kind or another. The principal directions of migration are illustrated by more or less continuous movements from rural areas towards the city, from areas of stable population towards centers of industrial or commercial opportunity, from densely settled countries to less densely settled countries and from the centers of the cities to their suburbs”.

Eisenstadt looks at migration as “the physical transition of an individual or a group from one society to another. This transition usually involves abandoning one social setting and entering another and permanent one”. But in this definition he has failed to explain the psychology of individual or

groups who are shifting from one geographical location to another. As compared to the above mentioned definitions of migration, definition of migration suggested by Weinberg appears relatively flexible because he considered human migration as the change of place permanently or temporarily for a particular duration of time as in case of seasonal workers. If people maintain multiple residences in city, town and village, then his frequency of movement will help in deciding his status as a migrant. Even though many social scientists came forward to discuss and define the concept of migration but some of them have complicated its definition. But latest definitions of Zelinsky, Baker, Hagerstrand, Rose, etc are worth mentioning According to Baker, “migration is the act of moving from one spatial unit to another”. A broad area has been covered by this definition and also it touches a large number of branches of naturalists, social scientists, and others.

Hagerstrand has studied the Swedish migration fields and he has defined migration in terms of change in the centre of gravity and has defined that an individual’s mobility depends upon the change in the 117 Centre of gravity, for example termini of journey to work, recreational and shopping movements may remain same, while there will be change in interurban move. Another person who gave a comprehensive definition of migration was Arnold Rose. His definition establishes the relationship between migration and the growth of population although indirectly. According to him, migration does not add or subtract from the total population of world, but it can have hand effect on the total population by involving the movement of people from areas where they are likely to reproduce less to areas where they are likely to reproduce more or vice versa In the study of movement of people in Ghana, Fortes distinguishes mobility which he restricts to movement within boundaries and migration in which person crosses borders. In Indian context, this approach poses certain problems. Safa has expressed her view that “Migration is normally viewed as an economic phenomenon though non-economic factors obviously have some bearing. Most studies concur that migrants leave their area of origin primarily because of lack of employment opportunities and with the hope of finding better opportunities elsewhere”.

After evaluating all the definitions of different scholars we come to find out that most of them have stressed upon time and space but none of them has laid stress on socio- economic repercussion. After considering socio economic concept i.e. consequences of socio economic migration, a new definition will be required which will study three dimensions of human migration i.e. time, space and socio economic implications. Therefore, migration can be defined as permanent or semi permanent movement from one place to another which leads to culture diffusion and social integration.

The push factors are factors that compel a person, due to different reasons, to leave that place and go to some other place. The common push factors are low productivity, unemployment and underdevelopment, poor economic conditions, lack of opportunities for advancement, exhaustion of natural resources and natural calamities. Introduction of capital intensive methods of production into agricultural sector, and mechanization of certain processes reduce labour requirement in rural areas. The non-availability of alternative sources of income in rural area is also important factor for migration. The Pull Factors are factors which attract the migrants to an area. Opportunities for better employment, higher wages, facilities, better working conditions and attractive amenities are pull factors of an area.

6.3.1.1 Natural Factors

- Flood, famine, earthquake, tsunami etc.
- Natural disaster

6.3.1.2 Economic Factors

- Unemployment,
- Better employment opportunities,
- Increased input cost,
- Agrarian crises,
- Intense poverty

6.3.1.3 Social Factors

- Marriage
- Scope of better educational facilities,
- Scope of Medical facilities,
- Cultural or Recreational facilities

6.3.1.4 Political Factors

- Political instability

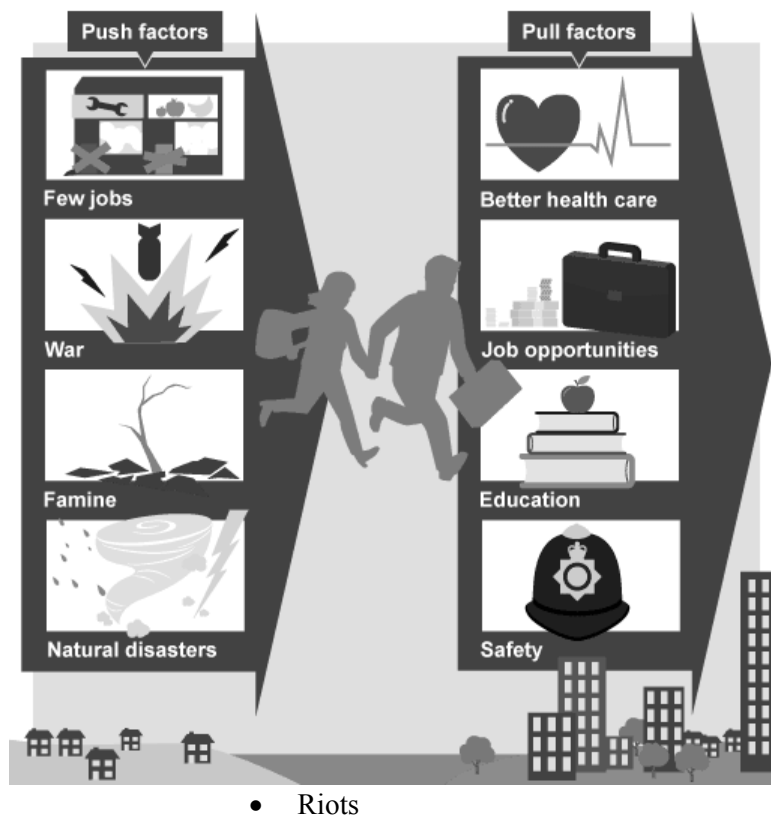


Figure 15: Factors of Migration

Source: Accessed from <https://www.jkgeography.com/migration.html>

Natural factors

Of the ecological factors that push individuals to migrate, climate change is, arguably, the most serious. Over the next decade, climate change has the potential to intensify the impacts of the social, political and economic push factors described earlier in this paper. Even if individuals affected by climate change move only short distances this has the potential to alter social, political and economic dynamics. The possibility of social issues arising increases when tribal, ethnic and religious groups that were historically separate are forced to intermingle due to traditional lands no longer being able

to support human settlement. Individuals engaged in agriculture, for example, could be forced to find alternative forms of employment as their land is no longer capable of producing or sustaining viable quantities of goods. Food and water prices are likely to increase in parts of the region due to greater scarcity of these resources. These burdens place additional strain upon the capacity of the state to ensure welfare for all and, in some cases, maintain its stability.

The observable impacts of climate change are likely to become more apparent over the course of the next decade. States must utilise this time to prepare for the increased migratory flows that will be a consequence of the inevitable disruption that will occur over the next century. Climate change will have an impact upon water resources, agriculture, food security, public health and, in some instances, threaten the very existence of some states. The impacts of climate change will be most apparent in developing countries which lack the wherewithal to adequately address, or adapt to, the changing environment.

Food and water security are expected to become more salient issues over the coming decades. The most recent Intergovernmental Panel on Climate Change report suggests that climate change will have its largest impact upon food security by the middle of this century. Regions that can no longer sustain agriculture are likely to experience rural to urban migration or, in some cases, increased levels of international emigration. Another factor that can worsen food insecurity is water security. Increasing water insecurity in parts of the IOR, especially, has the potential to influence international migration.

Individuals who are severely impacted by changing ecological conditions may choose to migrate from their home state in search of more favourable environmental conditions elsewhere. Those who choose to emigrate due to more frequent or more destructive natural disasters may identify as climate refugees and seek asylum in other countries less affected by climatic extremes. Climate refugees are defined as ‘people who have to leave their habitats immediately or in the near future, because of sudden or gradual alterations in their natural environment related to at least one of three impacts of climate change: sea-level rise, extreme weather events, and drought and water scarcity. This definition, however, has no standing in international refugee law and organisations, including the United Nations, prefer to use the term environmental migrant. Fearing that it is now too late to take action to prevent climate change the international community is preparing measures for adaptation. Environmental migration is one such adaptation measure that must be taken into greater consideration by the international community.

Political Factors

Social push factors can include ethnic, religious, racial, and cultural persecution. Warfare, or the threat of conflict, is also a major push factor. In the Australian context, most asylum seekers arriving by boat in the last decade have come from Afghanistan, Iran, Iraq and Sri Lanka. All of these countries, apart from Iran, have undergone extremely destabilising conflicts in recent years. On the other hand, while it is free of violent conflict, Iran has one of the worst human rights records in the world leading many of its citizens to seek asylum outside of its borders.

The politicisation of religious and ethnic identities has the potential to cause significant levels of conflict within states. Empirical evidence suggests that states undergoing a political transition from authoritarian rule to democracy are at greater risk of instability and internal conflict. Often these states lack the ability to properly respond to social instability. Several states within the Indian Ocean Region (IOR), including Burma, have recently begun to democratise while failing to simultaneously develop a shared national identity capable of tying together the various groups within their borders. In socially diverse states the potential for conflict may be greater than in more homogenous or inclusive

societies. The future level of migration from these countries is wholly dependent upon the longevity and severity of any conflict that could arise from social grievances.

Individuals migrating due to social or political conditions are more likely to do so as humanitarian migrants. This will have an impact upon where they settle as some countries have more liberal approaches to humanitarian migrants than others. In the first instance, these individuals are likely to move to the nearest safe country that accepts asylum seekers. This does not, however, prevent them from undertaking a second migration to a country that provides a broader range of legal rights to asylum seekers and refugees.

Economic Factors

Economic factors relate to the labour standards of a country, its unemployment situation and the overall health of its economy. If economic conditions are not favourable and appear to be at risk of declining further, a greater number of individuals will probably emigrate to one with a better economy. Often this will result in people moving from rural to urban areas while remaining within the confines of their state borders. As the low- and middle-income countries of today continue to develop and the high-income countries experience slower economic growth, migration from the former could decline.

Economic migrants are drawn towards international migration because of the prospect of higher wages, better employment opportunities and, often, a desire to escape the domestic social and political situation of their home country. These migrants are most likely to come from middle-income countries where the population is becoming increasingly well educated. Salaries and wages, however, are likely to remain relatively low compared to those of individuals with a similar educational background in other, higher-income countries. This disparity has the potential to lead to some highly-skilled individuals from developing countries migrating to more developed countries. This form of migration is known as south-north migration and has historically been the main form of economic migration.

In south-north migration, individuals from developing countries moved to more developed countries for work and sent remittances back to their country of origin. Over the past decade, however, south-south migration has become increasingly common. In 2013, south-south migration accounted for 36 per cent of all international migration while south-north movements accounted for 35 per cent. According to the Migration Policy Institute; migration between developing countries is built upon proximity, identity networks, income differentials and seasonal migration. For these reasons, 80 per cent of south-south migration occurs between states with contiguous borders where common cultural identities are likely to be found. The increasing prevalence of south-south economic migration is likely to continue as the barriers to migration are lower than south-north migration. Migrants from the south are generally less skilled and lower-educated than their counterparts from the north, making it difficult for them to migrate to more developed countries. Additionally, since migration occurs over smaller geographical distances it is potentially less disruptive to migrants and communities.

Technological advancement, both in communications and transport, in addition to the liberalisation of labour markets, has the potential to increase the rate of circular migration. This form of migration occurs when individuals migrate between an origin and a destination on several separate occasions. Generally, economic forces motivate individuals to move to countries where employment prospects are better before returning to their country of origin. Studies have shown that circular migration can have positive development outcomes. Most importantly, circular migrants are more likely to send larger remittances back to their country of origin than those who permanently settle within their destination country. Furthermore, issues relating to brain drain and a hollowing out of the labour force are largely averted.⁶ Problems of exploitation still remain, suggesting that efforts need to be made to ensure that standardised regulations are adopted to protect the rights of circular migrants.

Economic migrants have a greater degree of choice in determining their destination than humanitarian migrants. Many asylum seekers will flee to the nearest safe country that will accept them whereas economic migrants will move to countries that either require their skills or have better conditions than their country of origin. Pull factors within the destination country are therefore more likely to influence the decision making process of economic migrants.

Types of Migration

Internal migration: This refers to a change of residence within national boundaries, such as between states, provinces, cities, or municipalities.

International migration: This refers to change of residence over national boundaries.

Emigration: leaving one country to move to another

Immigration: moving into a new country

Return Migration: moving back to where you came from

Seasonal Migration: moving with each season or in response to labor or climate conditions

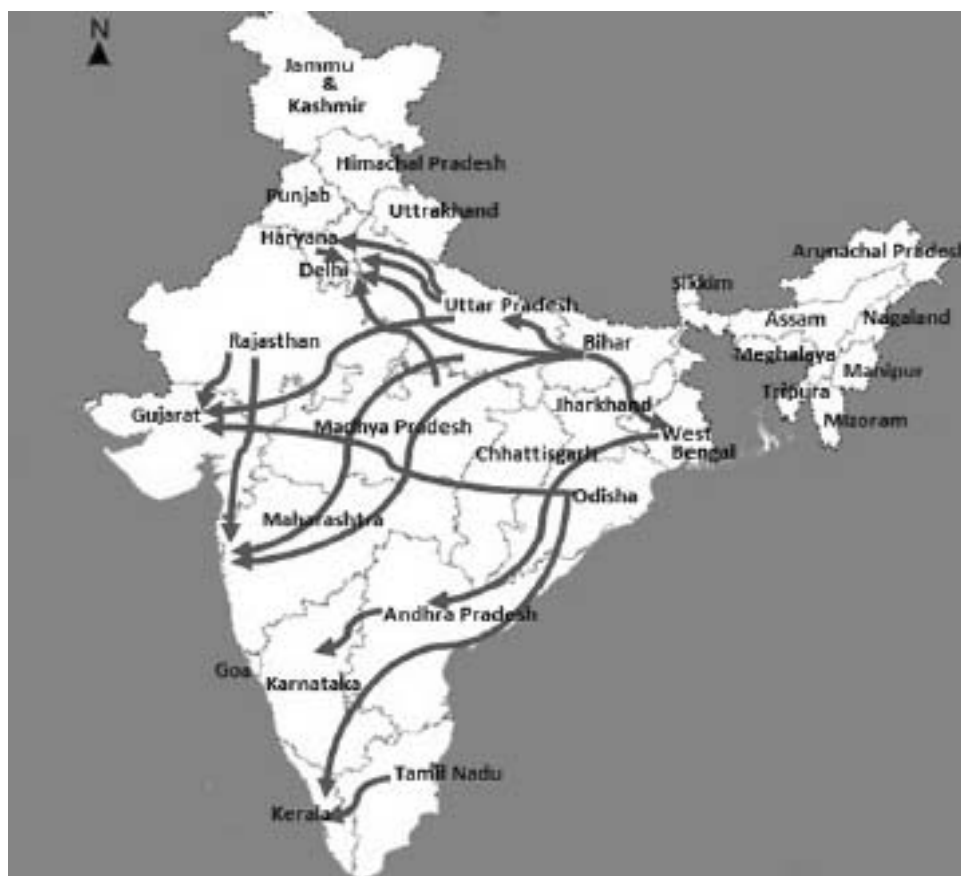


Figure 16: Internal Migration Flows, 2001 (Source:IIPS, Mumbai)

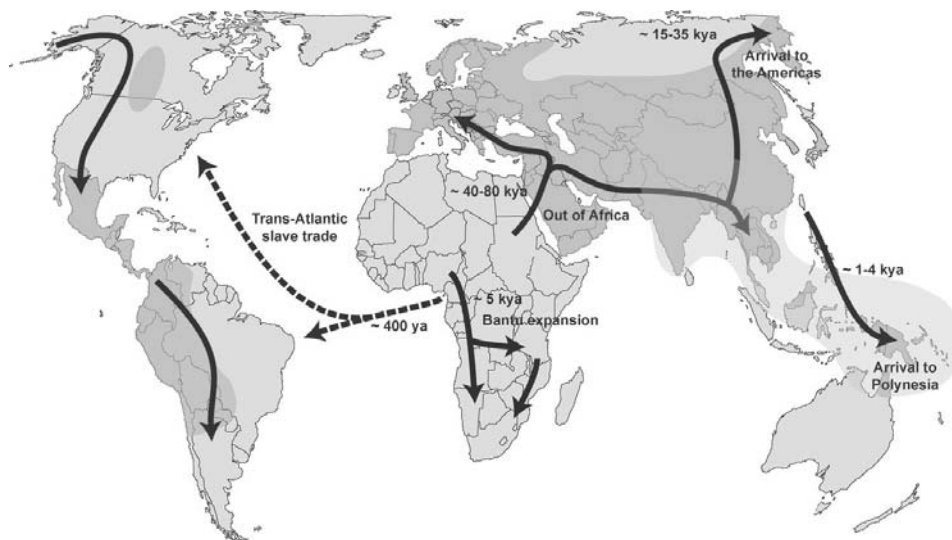


Figure 17: International Migration

The Impact of Migration

On migrants and their families Poorer migrant workers, crowded into the lower ends of the labour market, have few entitlements vis a vis their employers or the public authorities in the destination areas. They have meagre personal assets and suffer from a range of deprivations in the destination areas. In the source areas, migration has both negative and positive consequences for migrants and their families. Living conditions: migrant labourers, whether agricultural or non-agricultural, live in deplorable conditions. There is no provision of safe drinking water or hygienic sanitation. Most live in open spaces or makeshift shelters in spite of the Contract Labour Act which stipulates that the contractor or employer should provide suitable accommodation. Apart from seasonal workers, workers who migrate to the cities for job live in parks and pavements. Slum dwellers, who are mostly migrants, stay in deplorable conditions, with inadequate water and bad drainage. Food costs more for migrant workers who are not able to obtain temporary ration cards.

Health and Education

Labourers working in harsh circumstances and living in unhygienic conditions suffer from serious occupational health problems and are vulnerable to disease. Those working in quarries, construction sites and mines suffer from various health hazards, mostly lung diseases. As the employer does not follow safety measures, accidents are quite frequent. Migrants cannot access various health and family care programmes due to their temporary status. Free public health care facilities and programmes are not accessible to them. For women workers, there is no provision of maternity leave, forcing them to resume work almost immediately after childbirth. Workers, particularly those working in tile factories and brick kilns suffer from occupational health hazards such as body ache, sunstroke and skin irritation. As there are no crèche facilities, children often accompany their families to the workplace to be exposed to health hazards. They are also deprived of education: the schooling system at home does not take into account their migration pattern and their temporary status in the destination areas does not make them eligible for schooling there.

In the case of male-only migration, the impact on family relations and on women, children and the elderly left behind can be quite significant. Men add to material and psychological insecurity, leading to pressures and negotiations with wider family. Male outmigration has been seen to influence

the participation of women in the directly productive sphere of the economy as workers and decision-makers and increase the level of their interaction with the outside world. But given the patriarchal set up, women may have to cope with a number of problems which are exacerbated due to the uncertainty of the timing and magnitude of remittances on which the precarious household economy depends. This, in turn, pushes women and children from poor labouring households to participate in the labour market under adverse conditions. Thus, the impact of migration on the women can be two-sided but the strong influence of patriarchy restricts the scope of women's autonomy. The impact of male migration can be especially adverse for girls, who often have to bear additional domestic responsibilities and take care of younger siblings. The absence of male supervision further reduces their chances of acquiring education. There are several cases where women participate in the migration streams along with male members of their households. It is usual in such cases for younger siblings and older children to accompany their parents and to work along with them. Family migration usually implies migration of the younger members of the family, leaving the elderly to cope with additional responsibilities while at the same time fend for their subsistence and other basic requirements.

Changes in Migrants' Attitudes

Exposure to a different environment, including the stresses that it carries, has a deep impact on the attitudes, habits and awareness levels of migrant workers, depending upon the length of migration and the place to which it occurs. Changes are more dramatic in the case of urban migrants. Migrant workers develop greater awareness regarding conditions of work. Life style and changes in awareness may lead to a mixed impact on family members. The increased awareness which migrants, especially in urban areas, gain often helps them realise the importance of their children's education. Impact on source areas The major impacts of migration on source areas occur through changes in the labour market, income and assets, changes in the pattern of expenditure and investment. Although seasonal outmigration potentially has the effect of smoothing out employment over the annual cycle, rural outmigration could cause a tightening of the labour market in some circumstances. However, empirical evidence from out-migrant areas does not often attest to this. This may be because outmigration often takes place in labour surplus situations. There is also evidence of the replacement of out-migrant male labour by female and even child labour. Srivastava's (1999) study of seven villages in Uttar Pradesh showed some variation over regions. While the situation in the study villages in Eastern and central Uttar Pradesh conformed to a situation of labour surplus, this was not the case in Western Uttar Pradesh where seasonal migration coincided with the agricultural peak season (Rabi) and employers complained of labour shortages. Significantly in all the regions studied, labourers on their part gave uncertainty of employment along with employment conditions and poor relations with their agricultural employers as the major reasons for outmigration. Even if labour tightening is not an outcome, outmigration may still speed up qualitative changes in existing labour relationships in rural areas, and thereby affect the pace of change. This may occur in several ways.

First, there is the well-documented impact of migration on attitudes and awareness as migrant labourers and return migrants are more reluctant to accept adverse employment conditions and low wages. Secondly, outmigration leads to a more diversified livelihood strategy. Combined with some increase in the income and employment portfolio of poor households, this may tend to push up acceptable level of wages (reservation wages) in rural areas and may make certain forms of labour relationships (as for example, those involving personalised dependency) less acceptable (Srivastava, *ibid*; cf. also Rogaly et al, 2001). Outmigration as a result of debt at home, or debt-interlocking (i.e. the repayment of debts through advance labour commitment) involving employers in the destination areas or their middlemen, is quite common. Such outmigration may or may not eliminate the causes of debt. The reduction of personalised dependencies or interlocked relationships may also accelerate

labour mobility and migration as labourers seek out alternative sources of cash income (Srivastava, 1987; Breman, 1974, 1985; Mosse et al, 1997).

Remittances and Effect on Sending Areas

While the impact of outmigration via the labour market has been reviewed above, the other source of changes which need to be analysed would work through changes in income, income distribution and the pattern of expenditure and investment. Although we do not have direct evidence of the value of remittances from migrants, some indirect evidence can be adduced from the NSS surveys on migration and consumption and employment/ unemployment. These surveys give the percentage of out-migrants making remittances and households receiving remittances and depending upon remittances as their major source of livelihood. The former estimates depend upon the definition of out-migrants, which can vary. In 1992–93, 89% of permanent out-migrants sent remittances. The percentage of all rural households receiving remittance income is also fairly high – in some regions of the country, one-quarter to one-third of the households receive remittances. It should be noted that remittances are only one form in which resource flows occur as a result of migration, the other being savings brought home by migrants in cash or kind. Field studies show that a majority of seasonal migrants either remit or bring home savings.

However, the cash incomes which accrue may not always add to the resource base of migrant households as some are used to adjust earlier debts (NCRL, 1991; Mosse et al, 2002). However, it does appear that the income and consumption level of migrant households is generally higher than that of similarly placed non-migrants. But this conclusion needs to be carefully linked to migration impact as it is generally based on ex-post cross-sectional comparisons. As Mosse et al (2002) have noted, and as other studies testify, migrants are not only differentially placed at the entry point, their differential status also leads to different trajectories, so that changes in post-migration average incomes may provide only a limited picture of the varied set of changes. One of the few careful ethnographical studies (Rogaly et al, 2001) provides some evidence of improvement in incomes of seasonal migrants as a result of migration, but these conclusions need to be supported by other studies. The impact of migration on income and asset inequality is limited. The ethnographical study quoted above (Rogaly et al, 2001), finds evidence of reduced inequality, as incomes of labour households rise against non-labour households.

In another context, Mosse et al (1997) suggest that these inequalities increase because the differentiated nature of the migration process led to the amplification of income and asset inequalities. Remittances are mainly used for purposes like consumption, repayment of loans and meeting other social obligations. These constitute, in effect the ‘first charge’ on migrant incomes. The evidence on investment is, however, mixed. Investment by migrant households on housing, land and consumer durables is common and migrant income is also used to finance working capital requirements in agriculture. Evidence of other productive farm or non-farm investment is scarce but a number of studies do report such investment by a small percentage of migrant and return migrant households. Thus, while studies do not fully discount for the impact of some factors such as the life cycle effect, rural outmigration appears to provide some, albeit slender, evidence of an improvement in the productive potential of source areas, and the ability of some poor migrant households to acquire small surpluses and strengthen their productive base and bargaining strength in the rural economy.

The question of social and economic mobility can be examined both from the changes in worker occupations in the destination areas, as well as in the source areas. As shown earlier, a very large proportion of short duration migrants are unskilled. The question of their mobility is linked to their circumstances of migration, its duration, and is highly gendered. On the whole, a very small proportion of male migrants achieve economic mobility in the destination areas. The limited mobility

occurs as migrants acquire a foothold in the destination areas, or acquire some skills, and are thus better positioned to exploit the labour market situation. In the source areas, there is a slightly greater impact on social and economic mobility, which, however, generally eludes the poorest, and in most cases, is not substantial for poor migrants.

A major linked issue is the role of rural outmigration in the material and social reproduction of rural households and the extant relationships in which they are placed. Standing (1985) has argued that circulatory migration in particular contributes to the stability of rural production relations. He argues that circulatory labour migrations has 'safety valve' features and 'has often been a mechanism preserving a social mode of production or at least reducing the pressures on it' (ibid p. 8). Temporary migration may allow households to relieve underemployment and meet debt and other obligations without having to sell assets. 'Relay migration' can also be seen as a part of the household survival strategy. Indeed the long history of rural outmigration in some of the source areas in India combined with agricultural and rural stagnation seems to corroborate the stabilising role of outmigration. But labour circulation as well as other forms of rural outmigration can also disrupt pre-existing production relations (Standing, ibid). The major impact on source areas appears to be through the labour market, with recent evidence indicating greater mobility of rural labour households leading to a less isolated and more generalised agriculture labour market and an upward pressure on wages.

Further, as we have shown, there is also evidence of some impact through improvement in the resource base of the migrant households (Srivastava 1998). Impact on destination areas There are clearly multiple rationales for the use of migrant labour in destination areas. While shortages of local labour provides one important rationale, virtually all available evidence shows that recruitment of immigrants is as much motivated by strategies of labour control and wage cost reduction. Numerous cases have been documented where the same areas export and import labour to identical sectors.³ Migrants are preferred because their labour is easier to control and it is easier to extract labour from them under arduous conditions. Moreover, the supply of labour can be easily increased or decreased with little cost to employers and migrants can work for long and flexible hours. Flexibility of the migrant workforce is reinforced because of the role of contractors and middlemen in recruitment and supervision. The segmentation of the labour market, which also leads to greater control over both migrant and local labour, is another outcome of the process. Finally, the wage payment systems which grow around industries based predominantly on migrant labour are eminently suited to side-stepping minimum wage legislation.

The labour market outcomes generated by labour immigration facilitate a certain kind of growth and accumulation in the destination areas, although this is via what can be described as a 'low road' to capitalism. According to Breman (1996) the basic rationale for the growing informalisation, two-way mobility of labour and segmentation is to be found in the type of mercantilist capitalist development witnessed in India, just as international migration is strongly related to the structure of international capitalism (cf. Sassen, 1988; Piore, 1990). Capitalists operate in uncertain markets, under circumstances in which they are highly dependent on traders. Labour immigration is one of the strategies favoured by entrepreneurs to shift both risk and cost of production on to workers. Another reason for continued informalisation is to keep businesses away from state surveillance. Thus most enterprises in the informal sector escape regulation of any kind. Furthermore, in such destination areas, employers rarely provide anything other than wage subsistence requirements. Migrant labourers have to fend for themselves to meet their health, shelter and other basic requirements. Although the poor condition in which labourers subsist is a result of employers not internalising the legitimate costs of hiring labour (contravening numerous laws), to society the resulting urban congestion appears to be result of unplanned mobility. The costs of population mobility have been, as a result, considered in theory in the context of large costs imposed by population concentration in large cities. The social, political and other consequences of immigration, especially where such migration is by linguistically,

ethnically or regionally distinct groups, has not been considered in the growing economic literature on internal migration, but figures prominently in the corpus of sociological and political literature (cf. Weiner, 1978).

Government Legislation and Policies Labour Laws and Policies

The Indian Constitution contains basic provisions relating to the conditions of employment, non-discrimination, right to work etc. (e.g., Article 23(1), Article 39, Article 42, Article 43). India is also a member of the ILO and has ratified many of the ILO conventions. These provisions and commitments, along with pressure from workers' organisations, have found expression in labour laws and policies. Migrant labourers face additional problems and constraints as they are both labourers and migrants. Many of the problems faced by migrant labourers are covered by laws and policies in as much as they cover all labourers in a particular sector or industry. These laws include the Minimum Wages Act, 1948; the Contract Labour (Regulation and Abolition) Act, 1970; the Equal Remuneration Act, 1976; the Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996; the Workmen's Compensation Act 1923; the Payment of Wages Act 1936; the Child Labour (Prohibition & Regulation) Act, 1986; the Bonded Labour Act, 1976; the Employees State Insurance Act, 1952; the Employees Provident Fund Act, 1952; and the Maternity Benefit Act, 1961. The last three Acts cover only organised sector workers and thus preclude temporary migrants. In addition to the above laws, Parliament passed the Inter State Migrant Workmen (Regulation and Conditions of Service) Act 1979 specifically to deal with malpractices associated with the recruitment and employment of workers who migrate across state boundaries. The Act followed the recommendations of a committee set up by the Labour Ministers' Conference in 1976. The Act covers only interstate migrants recruited through contractors or middlemen and those establishments that employ five or more such workers on any given day.

Under the Act:

- Contractors and establishments are required to be licensed and registered by a notified registering authority.
- The contractor is required to issue a passbook to every worker, giving details about the worker, including payments and advances, and pay each worker a displacement allowance and a journey allowance.
- Contractors must pay timely wages equal to or higher than the minimum wage; provide suitable residential accommodation, prescribed medical facilities and protective clothing; and notify accidents and casualties to specified authorities and kin. The Act lays down machinery to resolve industrial disputes and provides for migrant workers to approach the authorities in destination states or in their home states if they have already returned home. The Act sets penalties including imprisonment for non-compliance, but provides an escape route to principal employers if they can show that the transgressions were committed without their knowledge. Labour laws aiming to protect migrant workers have remained largely on paper. In the case of the 1979 Act, few contractors have taken licences and very few enterprises employing interstate migrant workers have registered under the Act. The record of prosecutions and dispute settlement has been very weak. Migrant workers do not possess pass books, prescribed by law, and forming the basic record of their identity and their transactions with the contractor and employers (NCRL 1991, GVT, 2003). A study conducted on the status of migrant workers in the Punjab by the Centre for Education and Communication (CEC) pointed out gross violations of the Child Labour (Prohibition & Regulation Act 1986), the Minimum Wages Act (1948), the Contract Labour Act (1970), the Inter State Migrant Workmen Act, 1979 and the Equal Remuneration Act (1976). The violation of these laws was found to be most rampant in the

case of brick kilns. Different kinds of harassment were meted out to migrant workers by the police, postal department, owners of the establishments, owners of workers' dwellings, shopkeepers, labour contractors and the railway police during their journey. Migrant labour is recruited from various parts of a particular state through contractors or agents for work outside that state in large construction and other projects. This system lends itself to abuses – working hours are not fixed and workers have to work under extremely harsh conditions (<http://www.labourfile.org/cec1/cec>).

A similar situation was reported by Rani and Shylendra (2001) in their study of construction sites in Gujarat. Legislation fails because regulatory authorities are over-stretched, the state lacks commitment and migrant workers are weak and vulnerable with little support from civil society. Most migrant labourers are also employed in the unorganised sector, where the lack of regulation compounds their vulnerability. Following the recommendations of the Second National Commission of Labour (NCL, 2002), the central government has mooted a draft law (The Unorganised Sector Workers Bill, 2003) in order to identify workers employed in the unorganised sector and to provide them with basic social security. The Bill builds upon the experience of tri-partite welfare funds already in existence for a few industries in some states.

Key Provisions of the Proposed Act Include

- The scope of the Act will extend to all workers in the unorganised sector, whether directly or through an agency or contractor, whether for one or several employers and whether a casual or temporary worker, a migrant worker, or a home based worker (self-employed or employed for wages).
- Central and state governments shall constitute an 'Unorganised Sector Workers' Central Board' and similar state boards for the administration and coordination of the Act at central and state levels.
- The boards shall set up 'Workers Facilitation Centres' for the registration of workers; issue of social security numbers and identity cards; mobilisation of workers to become members of the Welfare Fund; assistance in dispute resolution and in the conduct of inspections.
- Concerned governments could notify welfare schemes for any class of employment under the Act and establish a Fund for this purpose. It could also regulate the conditions of employment.
- The Welfare Fund will receive contributions from the government, employers and workers. Workers will have to make regular contribution to the Fund until the age of 60.
- All workers, including self-employed or home based will be eligible for registration.
- Lok Shramik Panchayats shall be formed for dispute resolution in the unorganised sector.
- The government will appoint persons known as Shramik Samrakshak to carry out inspections and check on the compliance of the Act. Although broad in intent, the Act does not make registration or contributions to the Fund mandatory, remains trade/employment specific and the creation of the Fund itself will depend upon the relevant Board and its financial considerations.

However, this is the first time that the government of India has conceived of a comprehensive law to cover all unorganised sector workers including migrants, and its scope and content need to be debated in all forum concerned with the welfare of such workers. Other areas of government intervention and policy Apart from labour laws, a whole gamut of governmental interventions and policies in favour of the poor also impinge upon migrant workers. However migrants often fail to benefit. Participatory poverty assessments in Madhya Pradesh show that migrant labourers are not able to participate in the gram sabha meetings which identify beneficiaries for government programmes (PRAXIS, 2002). This is particularly true in cases where entire families migrate out. Schooling of children is a major problem for migrants and, not surprisingly, several studies find that

the hard-core of educationally under-privileged children belong to migrant families. Even in cases where men alone migrate, women in poor households are unable to take appropriate schooling decisions and supervise school-going children. (In the case of slightly better-off migrant households, however, migration may lead to a better recognition of the value of education.)

The Lok Jumbish programme in Rajasthan became the forerunner of programmes of education focusing on migrants' children. Migrants suffer from a lack of access to health services both at home and in the work places, although they are known to be especially vulnerable to health problems, and can serve as carriers of communicable disease. The issue remains largely unaddressed although seasonal migrants to rice fields in West Bengal have some access to doctors through their employers. The recent international focus on HIV/AIDS has galvanised governmental attention on the link between migration and the spread of this disease, and has resulted in a large number of NGOs working with migrant workers under the National AIDS Control Programme, but other health related problems of migrants continue to receive short shrift. Government employment and watershed programmes have the potential to increase employment in dry and rain-fed regions and reduce distress migration.

Together with well-executed public employment programmes, watershed development programmes resulted in lower levels of distress migration following drought in Madhya Pradesh in 1999–00, and 2000–01 (PRAXIS, 2002). This was also the case with food-for-work programmes in several drought affected states in 1987–88, but institutional break down and lack of political commitment prevented a similar impact in recent drought years. The Maharashtra Employment Guarantee Scheme (EGS), which has been operational since 1975 and which assures employment to labourers in public works, has succeeded to some extent. The overall picture, however, is one of neglect: unwitting or otherwise. Thus, as with labour policies, few other government strategies have begun to accord visibility to migration, and build in issues of migration in the design and implementation of programmes.

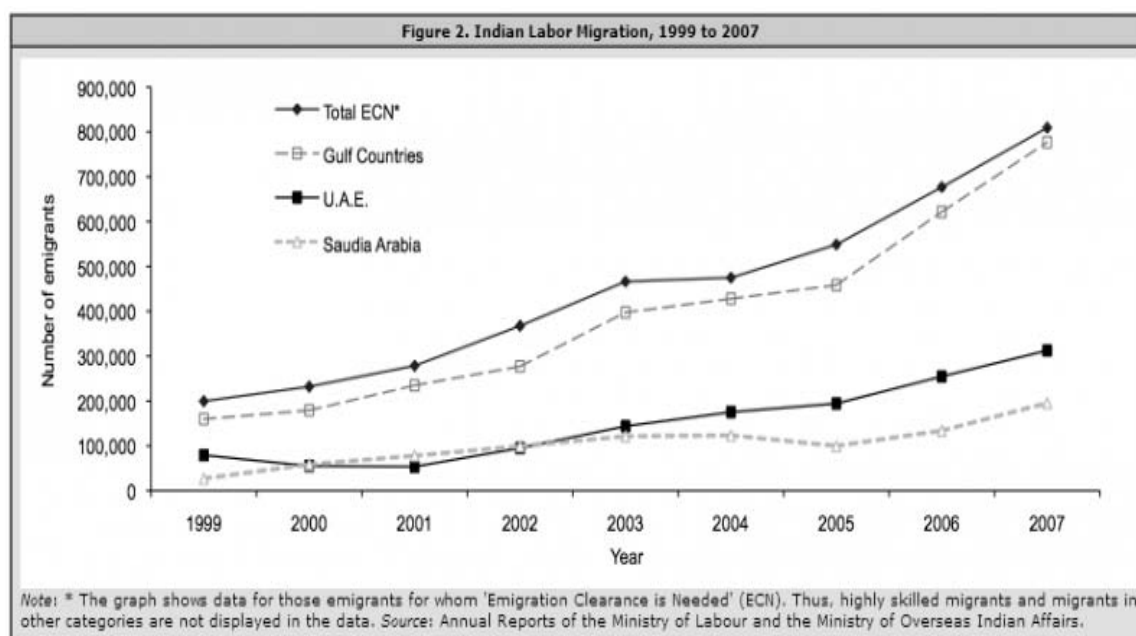
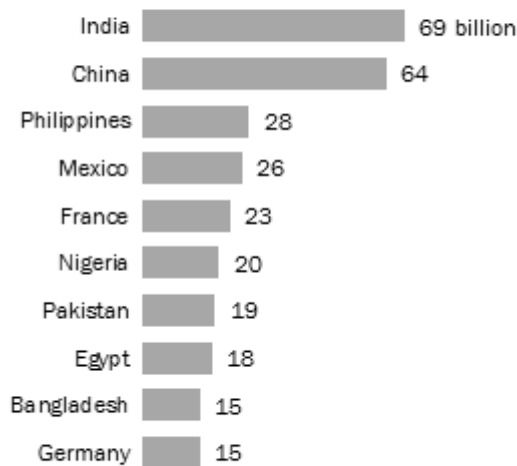


Figure 18: Indian Labour Migration, 1999 to 2007

India is the top recipient of the world's migrant remittances

Estimated 2015 remittances in billions of current U.S. dollars, by destination country



Note: Top 10 countries by remittances shown.
Source: World Bank.

Figure 19: Remittances Received by Different Countries

Theories of Migration

Ravenstein's Laws of Migration

Although migration phenomena have been studied by social scientists, thinkers, reformers and others from the very beginning of human civilization, the theoretical and empirical knowledge of migration has not developed to a considerable extent. That is why, even today this study needs migration theories, laws and models taking into consideration its spatial and temporal variations. Unlike physical laws, migration laws cannot be made rigid. Some hypothesis have been developed by social scientists and scholars, they have formulated a few theories and laws and have also suggested migration models.

It was in 19th century that theories concerning migration flow and other processes related appeared. There were three eminent scholars of population who made important contributions to population theory and analysis, they were: Robert Malthus (1766-1834), William Farr (1807-83), and Ernest George Ravenstein (1834-1913). Among these Malthus was the grand theorist, Farr was the statistical demographer and public health reformer and Ravenstein was inductive empiricist. Ravenstein was the empiricist who formulated laws concerning migration stream. According to him, "the laws of population and economic laws generally have not the rigidity of physical laws".

Most important statements of Ravenstein that appeared as laws or hypothesis of migration are as follows:

(1) Most of the migrants move only a short distance. Because of this drift nearby areas are only affected and not far off places. Long distance shift is characterized by a special case like a specialized job, technical education etc.

(2) The direction of migration is from agricultural to industrial areas. Rural and urban areas are specialized in different economic activities. Rural areas are dominated by the primary sectors whereas urban areas are specialized in secondary and tertiary occupations and because of this reason these two areas have distinct socioeconomic conditions.

(3) Most of the long distance migration is due to the major industrial and commercial centre. Because major industrial and commercial establishments need skilled labour and professionals, since they are not available locally, these persons travel from distant places.

(4) Migration occurs in a series of stages. A group of people residing very near to the developed area will enter into it and thus the gap created by them at rural area will be filled by people from more remote areas.

(5) Females are more migratory over short distances than males. There is predominance of males over long distance migration. Families rarely migrate over long distances.

(6) Internal migration is predominated by females whereas males dominate international migration.

Many scholars are of the view that Ravenstein's statements are not universally applicable, for example: he emphasized on predominance of short distance migration but now- a- days because of the development of the transport facilities; long distance migration is being encouraged. Again, he stressed upon the fact that migration increases with the development of industries and commerce but this relationship is not linear. Despite of all these criticisms, Ravenstein's laws of migration have proved to be of considerable stimulus because he has given simple statements about migration, which migrates, where they come from and go to.

7.0 The Demographic Transition Model

The Demographic Transition (DT) is the transition from high birth and death rates to low birth and death rates as a country or region develops from a pre-industrial, largely rural and agrarian society to an industrialized and urban society. The theory was proposed in 1929 by the American demographer Warren S. Thompson. Later on Frank W. Notestein developed a more formal theory of demographic transition. This theory has three basic assumptions as mentioned below:

- a) The mortality rate declines before the fertility rate starts to decline.
- b) The fertility rate declines to match with the declining mortality rate.
- c) The societal structure also transforms with the demographic changes taking place in it.

The transition involves four stages.

1) Highly Stationary with High Fertility and High Mortality Rates

In stage one, both death rates and birth rates are high and fluctuating due to large scale epidemics and deaths. The concept of family planning and contraception was not popular. Overall death rates matched with the birth rates, often more than 40 per 1000 per annum. Infant mortality rate is very high, often being 200 per 1000 in a year. Longevity is low. This is more common in pre-

industrial society. Population growth is typically very slow in this stage. Many African and mid-Eastern countries are still in this stage of demographic transition.

2) Early Expanding with Declining Mortality and High Fertility Rates

In stage two, the death rate drops quickly due to improvements in food supply, sanitation and vaccination programmes. It increases life expectancies and reduces disease. The improvements specific to food supply typically include selective breeding, crop rotation and farming techniques. However, the birth rate is still high. This is more common in case of developing countries.

3) Late Expanding with Low Mortality and Declining Fertility Rates

In stage three, birth rates fall due to various fertility factors such as access to contraception, increases in wages, urbanization, a reduction in subsistence agriculture, an increase in the status and education of women, a reduction in the value of children's work, an increase in parental investment in the education of children and other social changes. Population growth begins to level off. Most of the developing countries belong to this stage.

4) Low Stationary with Low Fertility and Low Mortality Rates

During stage four there are both low birth rates and low death rates. Birth rates may drop to well below replacement level. Death rates may remain consistently low or increase slightly due to increases in lifestyle diseases due to low exercise levels and high obesity and an aging population in developed countries.

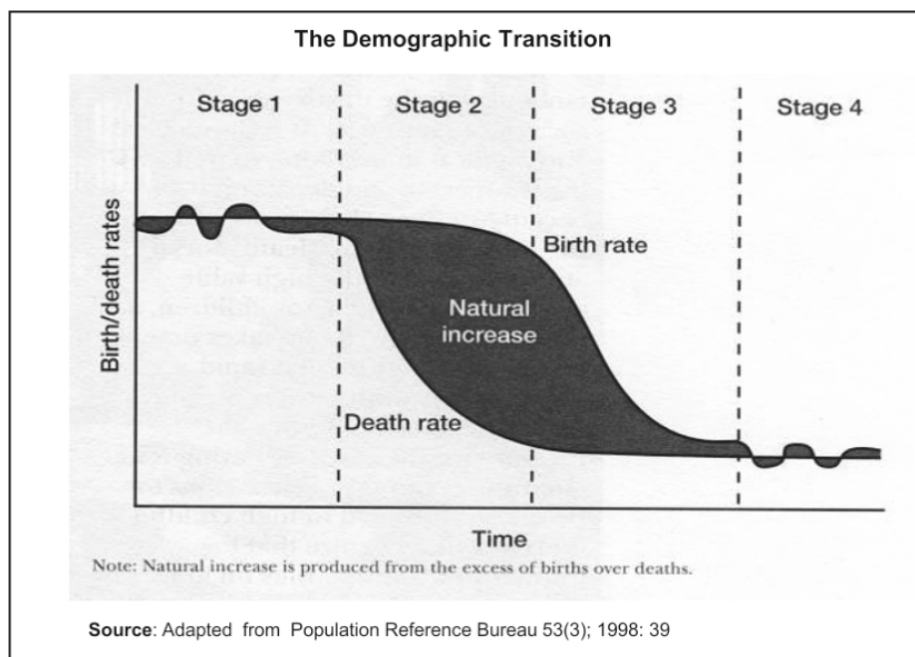


Figure 20: The Demographic Transition Model

Source: Accessed from http://www.searo.who.int/entity/health_situation_trends/data/chi/natural-population-growth-rate/en/

Criticisms

Despite its usefulness as a theory describing demographic transition in Western Countries, it has been criticised on the following grounds:

i. Sequences of Stages not Uniform

Critics point out that the sequences of the demographic stages have not been uniform. For instance, in some East and South European countries, and in Spain in particular, the fertility rates declined even when mortality rates were high. But in America, the growth rate of population was higher than in the second and third stage of demographic transition.

ii. Birth rate not declined initially in urban areas

Nolestein's assertion that the birth rate declined initially among urban population in Europe has not been supported by empirical evidence. Countries like Sweden and France with predominantly rural populations experienced decline in birth rates to the same extent as countries like Great Britain with predominantly urban populations.

iii. Explanations of birth rate decline vary

The theory fails to give the fundamental explanations of decline in birth rates in Western countries. In fact, the causes of decline in birth rate are so diverse that they differ from country to country. Thus the theory of demographic transition is a generalisation and not a theory.

In spite of these shortcomings, the theory provides an effective portrayal of the world's demographic history at macro level of generalisations.

Relevance of Transition Theory for Developing Countries

The relevance of transition theory for the present situation of developing countries is an important issue of both science and policy. From a scientific perspective, the weaknesses and ambiguities of transition theory in explaining European experience may be further examined if one follows the current and future demographic processes of developing countries.

The relevance of transition theory to the modern era may be of even greater interest to policy formulation. If it can be shown that within a reasonable period of time social and economic development cause a "natural" decline in fertility.

The differences which cumulatively militate against "natural" and timely fertility declines in the developing countries include at least the following:

A1) Pace and source of mortality decline

The declines in mortality of European countries were gradual, and were generally related to the social and economic forces of development and industrialization. The same is not true for many developing countries, where mortality declines have been far more dramatic and have often resulted largely from imported technologies which can be transferred with relative ease and are only marginally related to the pace and level of general development. The result is that mortality levels in developing countries are much lower than those of early industrial Europe, but the factors which brought this about may be less indigenous and hence have less impact upon fertility.

A2) Fertility levels before decline

Fertility in most developing countries today is much higher than in pre-transition Europe. For example, the birth rate in early 19th-century Britain is estimated to have been generally less than 35 per thousand, whereas in many countries today (such as Tanzania and Iran) it is over 45 per thousand, and in some (such as Afghanistan) possibly over 50. These higher birth rates are due primarily to the practice in most developing countries of early and near- universal marriage, in distinct contrast to the 19th-century European pattern of late marriage and extensive non- marriage.

A3) International migration

The untoward effects of too-rapid population growth in a given country can, in theory, be mitigated by international migration. In the 19th century the countries of Europe "exported" tens of millions of their citizens to the "new" continents of the Americas and Oceania and to overseas colonies elsewhere. Yet the political and economic realities of today mean that substantial international migration is no longer a potential outlet for excessive population growth.

A4) Rate of population growth

As a result of the above differences, all of which operate in the same direction, population growth in most developing countries is literally extraordinary- quite unprecedented in human experience, including that of the European transition. Growth rates of developing countries today range as high as 3.4 per cent (for example, in Algeria, Colombia, and the Dominican Republic, among others), with an average of about 2.5 per cent. At the former rate a population would double in size in only 20 years (and would increase 32- fold in a century); at the latter rate doubling would take less than 30 years. In contrast, European nations undergoing their demographic transitions rarely experienced doubling times of less than 50 years, and the average was about 90 years. Hence, at no point in their transitions did European countries sustain the rates of population-related growth in demand for basic necessities and for social investment that are now confronted daily by the leaders of many developing countries. Such demands often compete with those for investment in key physical resources in industry and agriculture, and can thereby serve to impede social and economic development. The perversely circular effect may be to slow or even short- circuit any underlying "natural" tendencies toward completion of the demographic transition which result from the forces of development.

A5) Momentum for further growth

The rapid growth of developing countries will be more difficult to halt than the slower growth of transitional Europe. As a result of their much higher fertility, modern developing countries have very much "younger" age structures than Europe had, and therefore a far greater momentum for further growth. For example, even in the unlikely event that fertility in developing countries declined within the next decade to the "replacement" level now characteristic of developed countries, the population of the developing world would nonetheless continue to grow for 60 to 70 years, and by the year 2050 would have reached a size nearly 90 per cent greater than its 1970 level. If replacement fertility is deferred until 20 years later, the increase would be over 150 per cent. For specific developing countries with unusually young age structures, the force of growth momentum under these two assumptions would, of course, be even larger.

A6) Opportunities of Jobs and rural-to-urban mobility

Occupational mobility away from agriculture and spatial migration from rural to urban areas provided alternative life opportunities for the increased rural population during the European transition. The

much more rapid natural increase of modern developing countries presents great difficulties to the provision of comparable opportunities for occupational and spatial mobility. The increase in demand for non-agricultural employment often exceeds the increase in supply, and the extraordinarily rapid rates of urban growth in many developing countries are threatening to overwhelm their capacities of accommodation. Indeed, in some cases policies are being sought to reduce rural- to-urban migration flows although the population remains predominantly rural, thereby limiting the hypothesized effects of urban life upon family and reproductive values.

A7) Fewer opportunities for female participation in the labour force

There is some evidence that the increased entry of women into the non-agricultural labour force in Europe was a factor in fertility decline. If this is true, the more rapid rate of natural increase in developing countries today means that the entering labour force is growing faster as well. *Ceteris paribus*, this would tend to limit the growth in the demand for female labour.

A8) Difficulties of providing universal education

With school-age cohorts doubling in only two or three decades, many developing countries are understandably experiencing difficulties in expanding educational facilities at a rapid enough rate to provide educational opportunities for a growing proportion of those eligible. This means deferment of the goal of universal education, along with its hypothesized effects upon fertility behaviour in the transition.

There are also differences between the situations of the European transition and those of modern developing countries which tend to favour more prompt and rapid fertility declines in the developing countries:

B1) Pace of social and economic development

For many developing countries, social and economic development has been more rapid than in 19th-century Europe. To the extent that such development "causes" or expedites the decline in marital fertility, this suggests more rapid completion of the demographic transition as well.

B2) Methods of fertility control

The European fertility declines appear to have been based upon increased and more effective use of traditional fertility control measures such as coitus interruptus and abortion, although by modern standards the effectiveness of the former was not high and the danger of the latter was great. Improved contraceptive technology and safe abortion techniques have now been developed, and additional approaches such as safe and acceptable voluntary sterilization are available for the first time in history. At any given level of motivation to control fertility, access to such improved methods is likely to mean more frequent and effective practice, with consequently greater demographic effects.

B3) Greater latitude of deferment of marriage and increased non-marriage

The European demographic transition began in the context of late marriage and extensive non-marriage. In developing countries, today marriage is generally early and almost universal. Hence, although the 19th-century European transition relied primarily upon reduction of marital fertility (indeed, marriage occurred earlier and became more frequent, which tended to increase overall fertility), fertility in developing countries may be reduced via changes both in marriage practices and

fertility within marriage, and will at least not tend to increase as a result of earlier marriages and higher marital frequencies.

B4) Increased legitimacy of the small family norm

The large family was taken as "normal" in most of 19th-century Europe; there were few obvious examples of alternatives, and cultural diffusion was in any case relatively limited. In contrast, the "demonstration effect" of the European transition has provided modern legitimacy for the small family norm and evidence that its achievement is feasible, and many factors (such as improved international communication and expanded trade) have accelerated the processes of cultural and intellectual diffusion. B5) Increased interest and planning capability of government. Population growth rates in 19th-century Europe, high by historical standards (although low by 20th-century standards), were not considered to be excessive. In addition, many developing countries now have economists and planners able in principle to foresee future problems, whereas such planning at a national level was little known in 19th-century Europe.

B6) Governmental ability to permeate subnational linguistic/cultural barriers

Evidence from the Princeton European Fertility Study demonstrates the importance of subnational linguistic/cultural barriers in limiting or delaying the spread of the European demographic transition. Unlike much of 19th-century Europe, most modern developing countries have the administrative and technological infrastructure (for example, central planning and administration, widespread publication in multiple languages, improved transport, telecommunications, radio and TV, and postal systems) to enable them to better permeate such barriers.

B7) International assistance

The present availability of international assistance (via the United Nations and other agencies) means that governments of developing countries may call upon substantial outside resources and expertise. Such assistance, if employed properly, can reduce delays in development processes which might otherwise result from indigenous shortages of capital, materials, technology, and know-how.

B8) More rapid pace of fertility decline

This phenomenon may be attributable to varying combinations of the factors described above, especially more rapid development, sharper declines in mortality, greater governmental interest and capability, and the availability of effective contraception and safe abortion and sterilization. Summary and Conclusions When the available data on the 19th-century decline in European fertility are analyzed on a systematic basis, some major propositions of transition theory are empirically supported, but only those at a high level of generality. However, the more specific and explanatory propositions derived from transition theory cannot explain all of the salient features of the European experience. In particular, the theory fails to explain fundamental phenomena such as variations in pre-transition levels of fertility and in the timing of onset and the pace of the fertility decline which eventually became universal.

A recent study suggests that transition theory can achieve a similar moderate level of success in Latin America, especially when the traditional theory is substantially modified and additional causal variables including cultural factors are introduced. Once again the (modified) theory achieves considerable predictive power at a high level of generality-those Latin American countries with relatively high levels of development are more likely to experience the beginning of fertility decline than others. Again as in the European case, however, little success is achieved in predicting the timing

of onset and the date of progress of fertility decline on the basis of transition theory. Hence at high levels of generality the basic causal structure of transition theory appears sound. When the process of development is carried to the high levels achieved in Europe and some parts of Latin America, it appears to be sufficient to establish the preconditions for a natality decline. It cannot, however, be said to be necessary to this end, for these preconditions also arose in contexts of quite low social and economic development.

The substantially different socio-economic and demographic characteristics of modern developing countries leave little doubt that their patterns of fertility decline will differ markedly from those of Europe. Still, there is no reason to think that a high level of development will prove to be any less sufficient or any more necessary for the establishment of the preconditions for fertility reduction; indeed, there is already good evidence that fertility declines have occurred in areas of both high and low development. It must be recognized, however, that the high levels of development of Europe and parts of Latin America are not a realistic prospect for many developing countries, at least over the next few years or decades.

When transition theory is applied to such circumstances, it fails to provide adequate answers to two questions of fundamental scientific and policy significance: 1) Sufficiency: Will the moderate levels of development to which many developing countries can realistically aspire in the medium-term future be sufficient to establish the preconditions for "natural" fertility decline?

2) Timeliness: If such declines do occur, will they occur soon enough and at a pace rapid enough to compensate for the sharply increased pace of mortality decline and higher initial fertility levels of these countries as compared with transitional Europe? The current international debate hinges on these matters of sufficiency and timeliness. Those arguing that development will "take care of" population believe that development is sufficient (and also necessary) to bring about adequately prompt fertility reductions at an acceptable tempo. Those arguing in favour of voluntary population policies and programs-as additions to, not substitutes for, maximal efforts in the development sphere-emphasize the importance of development but doubt its sufficiency and timeliness for many countries, and hence call for direct efforts to enhance and accelerate its demographic impacts. Those urging coercive population policies accept the significance of development, approve of policies encouraging voluntary restraint, but hold that both of these are neither sufficient nor adequately rapid to meet the pressing need.

All agree with the general proposition of transition theory that high levels of social and economic development will eventually have important downward effects upon fertility. Hence the structure of these theoretical postures is pyramidal, with each finding scientific support in different aspects of the same basic orthodoxy. If this be so, it may well be asked why the debate about the modern relevance of transition theory is so strident, so lacking in scientific objectivity. The answer is the familiar one of politics, for over the past decade population has willy-nilly become an important issue of international affairs. In this arena, perspectives deriving from political rather than scholarly considerations have been wrapped in the scientific mantle of transition theory.

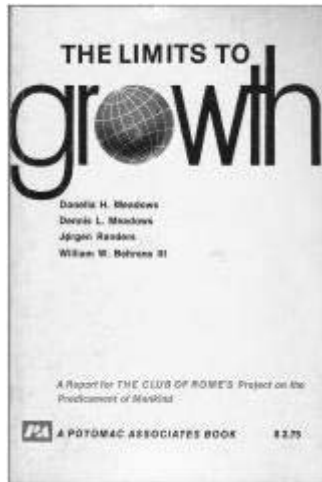
7.1 Limits to Growth

7.1.1 Introduction

The Limits to Growth (LTG) is a 1972 report on the computer simulation of exponential economic and population growth with a finite supply of resources. The report was written by Donella H. Meadows, Dennis L. Meadows, Jørgen Randers, and William W. Behrens III representing a team of

17 researchers. It was first presented at international gatherings in Moscow and Rio de Janeiro in the summer of 1971. A key idea in *The Limits to Growth* is the notion that if the rate of resource use is increasing, the amount of reserves cannot be calculated by simply taking the current known reserves and dividing by the current yearly usage, as is typically done to obtain a static index.

7.1.2 Message of the Book



The earth's interlocking resources – the global system of nature in which we all live – probably cannot support present rates of economic and population growth much beyond the year 2100, if that long, even with advanced technology. In the summer of 1970, an international team of researchers at the Massachusetts Institute of Technology began a study of the implications of continued worldwide growth. They examined the five basic factors that determine and, in their interactions, ultimately limit growth on this planet-population increase, agricultural production, non-renewable resource depletion, industrial output, and pollution generation. The MIT team fed data on these five factors into a global computer model and then tested the behaviour of the model under several sets of assumptions to determine alternative patterns for mankind's future. *The Limits to Growth* is the nontechnical report of their findings. The book contains a message of hope, as well: Human beings can create a society in which they can live indefinitely on the earth if they impose limits on themselves and their production of

material goods to achieve a state of global equilibrium with population and production in carefully selected balance.

7.1.3 History

In 1968, a group of about seventy five persons belonging to different strata of society from around the world founded the Club of Rome. It believed that the possibilities of continuous growth have been exhausted and timely action is essential in order to avert a planetary collapse.

It chose its initial theme “The Predicament of Mankind” in June 1970. It commissioned the research by four MIT scientists led by Donald Meadows which was published by the Club of Rome as *The Limits to Growth* in 1972. The second report entitled *Beyond Limits* was published in 1992 which gave fresh evidences as to how mankind has crossed beyond the limits.

7.1.4 The Model

It was Jay Forrester of MIT who in his book *World Dynamics* published in 1971 devised a model that investigates the interplay of such highly aggregated variables as world population, industrial world production, food supply, pollution and natural resources still remaining in the world.

Using the “system dynamics” methodology of Forrester, the authors of the *Limits to Growth* constructed an elaborate computer model of the world. They presented a large and new type of model designed to predict the future development of five global inter-related variables: population, food production, industrial production, non-renewable resources and pollution.

The model is based on the thesis that “the continued growth leads to infinite quantities that just do not fit into a finite world.” This basic idea has been elaborated in a highly complicated model which cannot be easily described in equation form. This is because the many relations between the five variables are not rectilinear.

The multipliers in question depend on the level of the variables. Among the various relationships, there are “feedback loops” that register the effects of changes in one variable such as food production on another variable like population growth. For example, population growth is positively related to food production. But food production is negatively related to pollution, and pollution, in turn, is positively related to industrial output. The model also uses past data on such factors as growth rates of population, industrial output and agricultural production, and the estimates of rates of technological progress. These factors would lead to the use of new resources, raise agricultural productivity and control pollution.

7.1.5 Assumptions of the Model

The assumptions of the model are based on highly non-linear relations:

- a. Population increase (the difference between the birth rate and the death rate) is influenced by crowding, food intake, pollution, and the material standard of living. A rise in any of these four factors tends to drive the birth rate downwards. The death rate decreases with increasing food intake and the material standard of living, and increases with increasing pollution and crowding.
- b. The material standard of living depends on the level of capital, relative to the size of the population and the productivity of capital.
- c. Non-renewable resources are continually used up by the production process. The lower the level of non-renewable resources, the more capital must be allocated to obtaining resources, and thus the productivity of capital for producing finished goods is less.
- d. Agricultural production depends on land and on capital investment in agriculture. Land can be developed or eroded, depending on investment decisions. Yield per unit of land can be increased by capital, but with diminishing returns.
- e. Pollution is generated by the production process and gradually absorbed into a harmless form by the environment. High accumulations of pollution, lower the absorbing capacity of the environment.

7.1.6 Operation of the Model

A major purpose in constructing the world model has been to determine which, if any, of these behaviour modes will be most characteristic of the world system as it reaches the limits to growth. The model shows four possible modes that a growing population can exhibit over time.

The mode actually observed in any specific case will depend on the characteristics of the carrying capacity. They are the level of population that could be sustained indefinitely by the prevailing physical and biological systems and on the nature of the growth process itself.

For example, a population growing in a limited environment can approach the ultimate carrying capacity of that environment in several possible ways. It can adjust smoothly to equilibrium below the environmental limit by means of a gradual decrease in growth rate.

The second possibility is that it can overshoot the limit and then lie back either smooth or in an oscillatory way.

The last possibility is that it can overshoot the limit and in the process decrease the ultimate carrying capacity by consuming some necessary non-renewable resources. The most characteristic of

the globe's population and material outputs under different conditions have been shown in these figures. The purpose of the model is to identify the future policies that may lead to a stable rather than an unstable behaviour mode.

7.1.7 Limits to Exponential Growth

Food, resources and a healthy environment are necessary but not sufficient conditions for growth. Even when resources are abundant, growth may be stopped by social factors. Of course, the society will not be suddenly surprised by the crisis point at which the area of land needed becomes greater than that available.

Symptoms of the crisis will begin to appear long before the crisis point is reached. Food prices will rise so high that some people will starve. Others will be forced to decrease the effective area of land they use and shift to lower quantity diets and thus caught in the death trap due to malnutrition.

There is a direct trade-off between producing more food and other goods needed by mankind. The demand for these goods is also increasing as population grows and therefore, the trade-off becomes continuously more apparent and more difficult to resolve.

If the first priority is to produce food continued population growth and the law of increasing costs could rapidly drive the system to the point where all available resources were devoted to produce food, leaving no further possibility of expansion. The exponential growth of demand for food supply results directly from the positive feedback loop that is now determining the growth of human population.

7.1.8 Non-renewable Resources

The resources that permit growth of capital stock tend not to be renewable resources but non-renewable resources. Are there limits to the earth's supply of these non-renewable resources? Even taking into account such economic factors as increased prices with decreasing availability, it would appear at present that the quantities of platinum, gold, zinc and lead are not sufficient to meet the demands.

Meadows concludes, "At the present rate of expansion....silver, tin and uranium may be in short supply even at higher prices by the turn of the century. By the year 2050, several more minerals may be exhausted if the current rate of consumption continues."

7.1.9 Pollution

D. Meadows is of the view that some pollutants are obviously directly related to population growth as in the case of agricultural land which is a non-renewable resource and its capacity to absorb excessive pollution is limited. While other pollutants are more closely related to the growth of industry and advances in technology.

Further, it is not known how much CO₂ or thermal pollution can be released without causing irreversible changes in the earth's climate. How much radioactivity, lead, mercury or pesticides can be absorbed by plants, fish or human beings before the vital processes are severely interrupted.

7.1.10 Predictions of the Model

The predictions of the Limits to Growth (LTG) Model are based on its basic thesis that "the continued growth leads to infinite quantities that just do not fit into a finite world."

This basic thesis can be analysed as under:

- (i) The future world population level, food production and industrial production will first grow exponentially, become increasingly unmanageable and then collapse during the 21st century.
- (ii) The collapse follows because the world economy will reach its physical limits in terms of non-renewable resources, agricultural land and the earth's capacity to absorb excessive pollution which are finite.
- (iii) Eleven vital minerals such as copper, gold, lead, mercury, natural gas, oil, silver, tin and zinc are being exhausted. If, in addition, industrial production continues to increase, that too will give rise to catastrophic results.
- (iv) If the present growth trends in world population, industrialisation, pollution levels, food problem and resource depletion continue unchanged, the limits to growth on this planet will be reached within the next one hundred years. The most probable results will be rather sudden and uncontrollable decline in both population and industrial capacity sometime before the year 2100.
- (v) Since technological progress cannot expand physical resources infinitely, it would be wise to put limits on our future growth rather than await the doomsday within the coming 50 or 100 years.
- (vi) This catastrophe can be averted by controlling the growth rate of output and population, reducing the pollution levels, and thus achieving a global equilibrium with zero growth.

Thus the Limits to Growth report developed an interactive simulation model that produced a variety of scenarios which were especially useful for defining what was to be prevented. It stressed that pollution, high population growth rate, and shortages of food and resources make the future prospects of the world bleak which will lead to catastrophic results.

Since the resources are finite and are likely to be depleted within 50 or 100 years, people should change their attitude towards the use of resources, their reproduction and pollution levels so as to save the world from collapse.

7.1.11 Graphic Explanation of the Model

The Limits to Growth Model is explained in Figure 20.2 (A), (B) and (C). Time in years is taken on the horizontal axis beginning from the year 1900 to 2100. In Panel (A), resources are measured along the vertical axis and are represented by the downward sloping R curve. Since such resources as oil, natural gas, copper, lead, etc. are fixed, they are being continuously depleted over time from the year 1900 and beyond 2100.

In Panel (B), the growth of population and food supply are measured on the vertical axis and are represented by the P and F curves respectively. They are shown to increase up to point E at the same rate from 1900 to 2000 year. But beyond the year 2000, the population curve P continues to rise, while the food production curve F rises at a diminishing rate and then starts declining by 2100. In Panel (C), the curve PL shows the pollution level which continues to rise beyond the year 2010 and if not checked in time, will lead to catastrophic results in the world.

7.1.12 Its Criticisms

The Limits to Growth was an alarming report predicting the collapse of the world economy in the 21st century. It sold ten million copies in over thirty languages and had considerable impact on economic

and political thinking and provided an impetus to anti-growth sentiment. In fact, the world community was divided into two groups: the resource pessimists and the resource optimists.

The former accepted the predictions of the report and the latter criticised them on the following grounds:

(a) Static Reserve Index:

The model has been criticised for assuming that the non-renewable resources are scarce and are likely to be exhausted by the year 2100. This perspective is based on the use of the static reserve index which is the ratio of current reserves to current use or consumption. The current reserves represent known resources that are economically extractable.

The index expresses the number of years until the resources are depleted, given that there will be no additions to the known resources and also the future annual use of the reserves remains at the current level. But the static reserve index is flawed because it neglects technological development in recycling and reuse of resources and the possibility of substituting scarce materials for abundant resources. Further, with the discoveries of new deposits of oil, gas, etc., the size of reserves may increase overtime despite their continuing extraction.

(b) Technological Development:

This model neglects technological developments in resource extraction, use and substitution. In fact, the size of reserves of non-renewable resources has been increasing due to rapid technological development which makes the extraction of sub-economic stocks of resources less expensive.

Moreover, the scarcity of resources has led to technological developments in new resources such as atomic energy, bio-gas, etc. for industrial and human use. According to Giddens, "It is the world of endless change and endless expansion which the LTG report overlooks."

(c) Food Production:

The model assumes the availability of limited land and consequent decline in food production. According to H. Kahn, "Whenever certain limits are reached, new technologies are introduced with the passage of time. These technologies effectively either remove the limit or as time passes a subsequent technology can remove the limit."

Kahn sees production rising with the invention of new technologies as in the case of the Green Revolution in developing countries which has increased food production and solved their food problem.

(d) Population Growth:

The model predicted that the world population growing at an exponential rate would be 7 billion in 2000. If the mortality rate continues to decline without lowering the fertility rate, it will be 14.4 billion in 2030. But the world population has not grown exponentially.

It was 6 billion in 2000, as against 7 billion predicted in the model. Highly populated countries like China and India have slowed down their population growth rate by adopting birth

control measures. Moreover, empirical studies have shown that economic growth accompanied by rising incomes lowers the fertility rate.

(e) Pollution:

The model assumes that the level of pollution is increasing exponentially in the world due to growth in agricultural and industrial activities. Consequently, the degradation of environment will adversely affect the quality and existence of human life, and flora and fauna.

No doubt, pollution of the environment is a serious problem, yet both developed and developing countries are trying to bring down pollution levels by using cleaner technologies. So there is no need for pessimism that pollution will bring the doomsday nearer.

However, pollution can be reduced by a judicious choice of economic and environmental policies and environmental investments. This is only possible through economic growth rather than by zero economic growth, as the model emphasises.

(f) Price System:

The LTG model neglects the price system and the dynamics of the market system. The model predicts that unlimited economic growth will lead to the depletion of non-renewable resources. But resource optimist economists do not agree with this view.

According to them, as the scarcity of resources increases, their prices will rise which will, in turn, affect non-renewable resources in four different ways:

- (i) With the rise in their prices, their direct consumption may be reduced;
- (ii) The use of high-priced resources in production will fall by substituting techniques that are less intensive in their use;
- (iii) High prices of non-renewable resources will encourage the search for new sources such as atomic energy for power generation; and
- (iv) Their high prices will provide incentives for the development of substitutes for these resources through new technologies such as bio-gas for power. Thus the efficiency of the market mechanism seems to be one reason why the gloomiest predictions for the depletion of non-renewable resources have failed.

(g) Zero Economic Growth:

The LTG report suggests a zero rate of economic growth in order to stop the rise in the pollution level. Critics point out that if a positive rate of growth will lead to doom, a zero growth rate will do the same but on a smaller time table. Instead, they argue that economic growth, especially in developing countries, will provide more resources that can be used to reduce pollution by supplying potable water, sanitation facilities, providing better housing facilities and reducing congestion in urban areas.

Moreover, economic growth is the only hope for developing countries to bring people out of the vicious circle of poverty and raise their standard of living. Thus the very idea of a zero rate of economic growth is fanciful.

7.1.13 Its implications

The Limits to Growth report highlights the dangers posed by the relentless pursuit of material wealth by the developed countries. It warns readers about the consequences of unconstrained growth by the industrialised countries.

The report calls forth policy makers, NGOs and the people in general to protect environment, save non-renewal resources and control population. Another important policy prescription of the LTG model is that the governments should voluntarily adopt a zero growth policy. Such a policy would require world redistribution of income and wealth. For zero economic growth, the redistribution of income and wealth both within and between countries would be on a very large scale. It can only be possible by force which would lead to upheavals between the rich and the poor. Moreover, the model fails to explain how redistribution of income and wealth can be affected with zero growth rate. Limits to Exponential Growth:

Food, resources and a healthy environment are necessary but not sufficient conditions for growth. Even when resources are abundant, growth may be stopped by social factors. Of course, the society will not be suddenly surprised by the crisis point at which the area of land needed becomes greater than that available.

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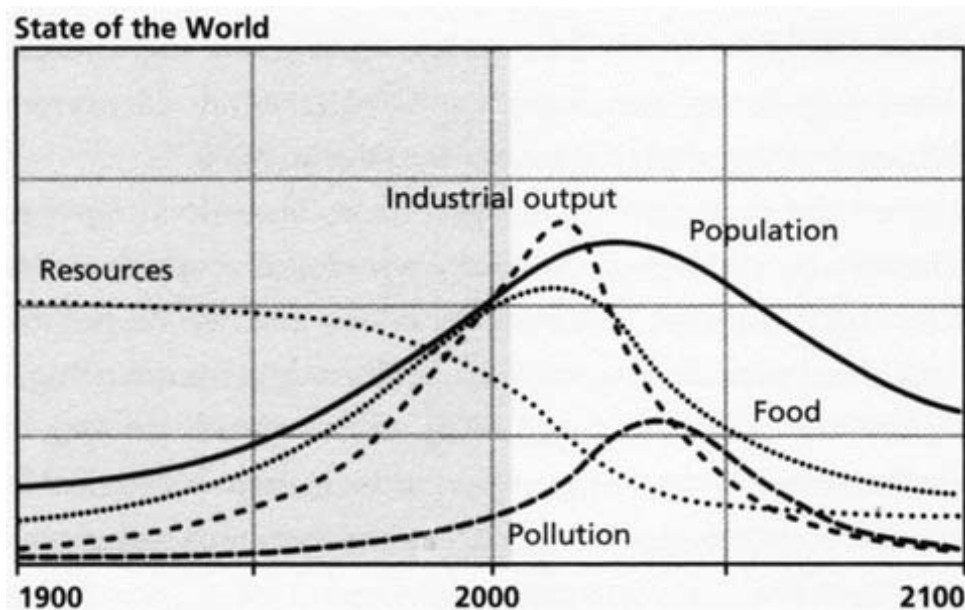
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8.0 Population Policies – Pro-Natal and Anti-Natal

From the writings of Plato (4th century BCE) on the population of the ideal Greek city, to the famous precept of Jean Bodin (1576) ‘the only wealth is man’, the desire to influence the size or composition of the population is an ancient one. The existence of an optimal population size for a given territory has long been a subject of debate among economists, and it is now being examined by ecologists.

Human population planning is the practice of intentionally controlling the rate of growth of a human population. It includes a set of measures taken by a State to modify the way its population is changing, either by promoting large families or immigration to increase its size, or by encouraging limitation of births to decrease it. Therefore, it is a deliberate effort of the Government to modify the existing demographic picture of the country through implementation of policies controlling fertility, mortality and migration. These policies may be categorised into two groups – pro-natalist i.e. policies favouring population growth, and anti-natalist policies which restrict population growth.

8.1 Pro-Natalist Population Policies

The aim of these policies is to increase the birth rate by limiting the access to contraceptives and abortions, also adding incentives of social and economic opportunities to boost the population growth. These are found in countries with either very slow natural increase or natural decrease, and in areas with ageing populations.



Source: <https://www.shutterstock.com/>

When a country is experiencing a negative population growth and an ageing population, it places great strain on social security systems due to decreasing income from taxpayers. A larger proportion of the population becomes increasingly dependent on a diminishing workforce. Countries with declining populations offer various incentives in order to try to raise fertility above replacement level fertility (2.1

children). This is experienced by countries that have entered and passed the fourth stage of the demographic transition model.

This might encourage governments to implement what is called a pro-natalist population policy. In other words, it motivates people to have more children. The incentives used includes social security benefits, child support, subsidised day-care, paid parental leave, incentives for women to work, tax reductions, equality bonus, financial aid and support, cheap transport and incentives for families to have larger family e.g. baby-bonus schemes.

Example – The Government of France, Sweden support pro-natalist population policy.

Pro-Natal Population Policy of Western Europe

In France and Germany, as well as in some other Western European nations, it is not hard to reach consensus on the goal of demographic policy: replacement-level fertility. What is more difficult is agreement on the means to achieve it. As in the 1930s, the political debate over low fertility is strongly influenced by ideologically inspired differences over what constitutes the "good society." It is hardly surprising that political views on an issue of such consequence for society should be shaped in part by the ideological preferences of political parties, and incorporated into their global visions of the ideal society. This was the case in the 1930s and it continues to be true today. Although there is considerable merging of views toward the centre of the political spectrum, there are nevertheless distinct left/right differences both in the significance attached to population growth and in the policy instruments the political parties choose to employ.

In Western Europe, both in the 1930s and today, rightist parties have chosen measures that would support the traditional family. An official of the family ministry in Bonn expressed it thus: "For the CDU [Christian Democrats], the starting point of the family is marriage. A family starts when a child is born to or adopted by a couple" (interview, 1985). In terms of reconciling parenthood and work, most right-wing parties would prefer to give women an "education allowance" to remain at home with young children. This type of measure is often justified by conservatives as giving a woman the choice between caring for the child herself or paying someone else to do so. Generally speaking, however, the suggested allowances are too small to compensate for loss of wages.⁸ Leftist parties, by contrast, generally dislike education allowances, arguing that they tend to put pressure on women to leave the labor

Instead, such parties usually attempt to provide sufficient places in day-care facilities for all children who need them. This is a much more expensive proposition that is seldom achieved, although attainment is becoming easier as the number of small children decreases. Deductions for dependent children from pre-tax income are another instrument frequently advocated by liberal and conservative parties, whose support often comes mainly from middle and upper income groups. Socialists, on the other hand, regard tax deductions as unfair to low-income families, who derive less advantage from them. Again, in recent years, some of the more extreme elements of the political right have become alarmed at the changes taking place within the family. As in the United States, they would like to limit the right to legal abortion, restrict the access of young people to contraceptives, and, somehow, discourage cohabitation outside of marriage. So far, governments of all political hues have resisted taking such steps; nevertheless, the principal measure introduced by the Conservative/Liberal coalition government in Bonn in its first years in office was the creation of a Mother and Child Foundation with limited funds to assist poor women who would otherwise terminate their pregnancies. Once elected to office, political parties must compromise, and governments in both France and Germany have deviated significantly from the positions they took while in opposition.

During the 1980s, new government coalitions-Socialist/Communist in France, Conservative/Liberal in West Germany-have been forced by economic and political pressures to modify their stance. The result, in both countries, has been a marked convergence toward the policies of the other side. To understand the nature of these shifts and how they came about, we will briefly examine the policy activities of the various governments of France and West Germany. In France, the first attempt in many years to strengthen the pro-natalist impact of family policy was undertaken in the mid-1970s under the centre/ right administration of President Giscard d'Estaing. Although Giscard spoke often of the importance of population growth for France's international standing, his policy instruments were weak. Simone Veil, his family minister until his last year in office, was a committed feminist who personally disliked the idea of stimulating fertility. It is doubtful whether Veil, whose chief accomplishment was to secure passage of a highly controversial bill to liberalize abortion, gave Giscard's pro-natalist initiative more than token support. In fact, a spokesman in her cabinet took pains to stress that the new pro-natalist policy was a personal initiative of the president, not of the minister (interview, 1978).

In the mid-1970s, moreover, Giscard had to tread carefully. In announcing his "new family policy" before the National Union of Family Associations (UNAF) in 1975, the president denied that it had any pro-natalist intent (Giscard d'Estaing, 1975). Steps were taken to remove a number of measures left over from the 1940s that were considered coercive. One of these was an additional

Pro-natalist Policies in Western Europe allowance payable for babies born within a specified period after their parents' marriage or after the birth of a previous child. In response to their demand for job security, many employed women were given the right to two years of leave after the birth of a baby; however, this leave was not compensated. For most of his term of office, Giscard's policy remained largely in the realm of rhetoric. Toward the end of the decade, Giscard got a chance to act. A survey conducted by INED (Institut National d'Etudes Demographiques) showed an upward movement, from two children to three, in "ideal family size," and women stated that poor economic conditions were preventing them from bearing a third child.

As a response, the amounts of several allowances payable for the third child were increased, yet the total still amounted to less than a professional wage. Economic conditions following the oil shock of 1979, and perhaps the president's lack of full commitment to the pro-natalist tack, precluded a serious effort to reverse the birth rate. Arriving in office in 1981, the new socialist government of President Mitterrand attempted to set in place a family policy that would be much broader in scope and more egalitarian. It was intended that family policy would treat all children equally, irrespective of birth order, and efforts were to be made to promote equality between the sexes. The overall aim was to reshape society in ways that would make childrearing less onerous. Within the family ministry, the secretary of state eliminated the most substantial of the special allowances created by Giscard for women having a third child, and simplified the family allowance system. But, as already mentioned, proposals to extend the family allowance to all children equally (including the first) were too expensive and had to be abandoned.

The financial crisis provoked by the Socialists' egalitarian measures marked a turning point in the Mitterrand administration's approach to family policy. Taking the initiative himself, the president returned to the less expensive expedient of placing the emphasis on the third child. The government has also introduced an allowance to cover the previously uncompensated right to leave from work following the birth of a baby. However, the benefit covers only the first 12 months of leave, and is available only to parents having a third or higher order child. In short, the difficulty of making ends meet forced the Mitterrand government into a policy hardly distinguishable from Giscard's. In West Germany, the first five years of the Christian Democratic/Liberal (CDU/FPD) coalition government brought fewer changes than might have been anticipated from the CDU's position while in opposition.

As in France, both political and economic realities tied the government's hands. Compared with France, Germany in the 1970s was an even less favourable place in which to elaborate a population policy. The end of National Socialism had left Germany without demographers and demographic research institutions; with a highly decentralized governmental structure; and with a strong aversion to the idea of population policy. This aversion is said to have been shared by Helmut Schmidt, who succeeded to office in 1974. Although the shortage of expertise

For the balance of the 1970s, the Social Democratic/Liberal (SPD/FPD) coalition government concentrated on educating itself on population questions. The Federal Institute for Population Research was created in 1974, and in 1977 an inter-ministerial working group was appointed to synthesize scientific and bureaucratic opinion on the societal implications of declining population growth.

After extensive review, the report was accepted virtually unchanged by the conservative government. The working group was then requested to examine whether it would be desirable to draft proposals for policy, but so far the group has not reported. In terms of policy, the Social Democratic/Liberal government attempted primarily to improve conditions for women: amid intense opposition from the political right, the laws on both abortion and divorce were liberalized. Nevertheless, despite the economic constraints, the child allowance was substantially increased in 1979. In the late 1970s the federal government also underwrote part of the cost of the economic program instituted in West Berlin in an effort to halt the heavy outmigration from that city. This was an exceptional move that reflected West Berlin's symbolic and strategic importance. Beyond this, most pro-natalist efforts made during Chancellor Schmidt's term of office were at the state level. Surprisingly, the instrument used by these governments was modelled on the family-formation grants employed by the National Socialists in the 1930s. Low-interest loans were made available to newly married couples to assist them with housing, and their repayment was to be cancelled gradually at the birth of each child, up to the third, born within a stipulated number of years.

In 1979, the opposition Christian Democratic/Christian Socialist parties made population and family a leading issue in their campaign for the federal elections of 1980, attacking the Schmidt government for what the conservatives called its "irresponsibility" in failing to deal with the population decline. There was a strong element of political sophistry in this tactic, however, as the opposition parties were well aware that no money would be available for population policy even if they were elected (interview with the CDU, 1978). In fact, as we have seen, one of the new government's first acts was to reduce the Kinder gelt and other allowances for families. More than five years elapsed before the Christian Democratic/Liberal coalition found it possible to carry out its election promises. As mentioned above, two expensive new pronatalist measures, an allowance to cover the cost of a year of "baby leave" and further tax deductions for dependent children, were announced late in 1984 and were scheduled to take effect in 1986. Within a few months, however, this pro-natalist thrust was counterbalanced by the announcement of a new, socially advanced policy for women.

The policy's aim is the achievement of full equality between the sexes, both at home and at work (German Tribune, 31 March 1985, p. 3). It was thought by some political elites in West Germany that this was a response to a sharp decline in the number of women's votes going to the government parties in the recent state elections (interviews, 1985). Irrespective of their ideological preferences, therefore, once in office governments in both France and Germany have adopted a highly pragmatic approach to low fertility. In concrete policy terms, there has been a convergence toward instruments that appeal broadly to the public. Except, possibly, for the new German measures, budgetary appropriations have been relatively modest. An immediate explanation for this low-key approach is the continuing economic weakness that has set a limit on governmental expenditures.

Amore fundamental explanation, however, is tied to the changes taking place in patterns of family formation: young people-and especially women-no longer want to be tied down by large families. This is one of the reasons behind the West German government's decision to move closer to the position of its center and left wings. As an official of the family ministry told this writer, "The CDU has realized that it must start where the people are" (interview, 1985).

In both France and Germany in 1985, informants spontaneously stated that there no longer exists a political lobby for the traditional family. In both countries, networks of family associations have long played a leading role in articulating the needs and demands of families. This is no longer the case. In Germany, as spokesman for the family ministry, himself a former family association employee, summarized the situation thus: "Remember, there are two sorts of power. There is the kind that comes from being listened to by government, and the kind that brings votes. The family associations only have the first kind." In France, the family associations no longer speak with one voice. In order to survive, these former bastions of tradition have had to open their doors to all comers-single-parent families, divorced and unmarried parents, cohabiting couples-whose interests often differ from those of traditional families. In sum, although they "are useful as critics," family associations are "too divided among themselves to make an effective lobby" (interview, Ministry of Social Affairs, 1985).

Furthermore, advocates of pronatalist policy in France no longer receive the volume of support that used to come from associations whose primary purpose was to lobby for such policy. Today there are only two nationally known pro-natalist associations, the century-old and highly respected Alliance Nationale: Population et Avenir, and the newer Association pour la Recherche et l'Information Demographique. Neither of these associations commands widespread support, and both operate on a shoestring budget. More significantly, both associations have been obliged to abandon the strongly pronatalist position characteristic of the past. Neither organization attempts to promote "la famille nombreuse" of former times; nor do they emphasize the third child in a family.



Plate: Pro-natal Population Policy

French Government Initiatives

- Payment of up to \$1640 to couples having third child.
- Generous maternity grants.
- Family allowances to increase the purchasing power of three child families.
- Maternity leave on near full pay ranges from 20 weeks for the first child to 40 or more for a third

- Full tax benefits to parents until the youngest child reaches 18.
 - 30% fare reduction on all public transport for 3 child families.
- Pension schemes for mothers / housewives.
- Child orientated development policies e.g. provision of day nurseries and more.
- Depending on the family income, childcare costs from virtually nothing to around €500 a month for the most well-off
 - Nursing mothers are encouraged to work part time or take a weekly day-off work.
- Social protection benefits for the families in Europe.

As a result of the decline in the birth rate, in 1984 the Singapore government started to reverse the anti-natalist policy. In 1987 some pro-natalist policies were introduced. They announced 'Have three or more, if you can afford it'.

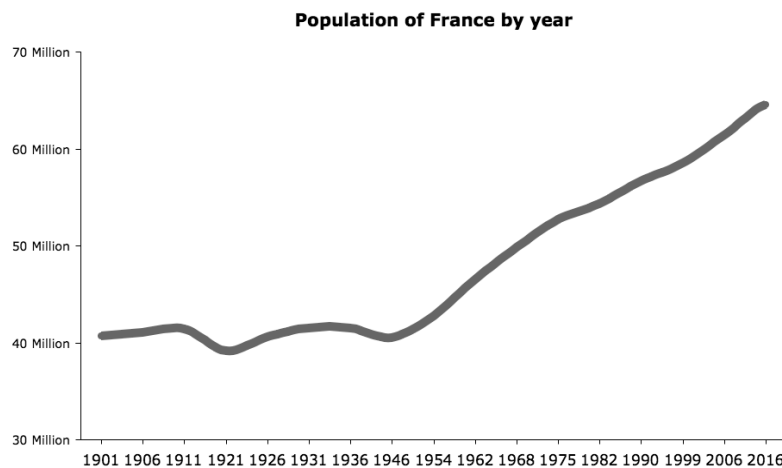


Figure 22: Population Growth in France, 1901-2016

Swedish Pro-Natalist Policies

- Parental leave, now with a benefit at 80% of earned income, for 13 months, plus 3 more months at a relatively low benefit not related to income;
 - Great flexibility through part-time use and varying take-out over time;
 - unconditional right to part-time work;
 - right to return to work.
- Speed premium when there are no more than 30 months between children.
- "Daddy days": Ten benefit days are awarded to the father in connection with each childbirth.

- Time for sick-child care, now up to 120 paid days per year per child (covers sickness of care personnel also).
- Cash child-benefit, currently at about 900€ per year per child. Also house-rent support in case of need.
- All-day day-care and all-day schools: high-quality low-cost public coverage that fully meets demand for children in all age groups, also for school-children.

A Comparison between Swedish and Germanic Pro-Natal Population Policy

The content and tone of those public statements are noticeably different in the two countries, however. There are not only factual policy differences between Germany and Sweden; those differences also reflect differences in mentality and in policy goals. In Sweden (where public engagement in family policies seems much the stronger) there is a determined egalitarian drive, and public financed campaigns are conducted to influence public opinion further toward gender equality. There is also a broad political consensus about the general goals in Sweden.

By contrast, there are marked political differences among parties and interest groups regarding family policies in Germany and with few exceptions the public statements that I have noticed largely seem to refer to impossibilities induced by the federal constitution. In Sweden, there have been continual efforts to build out the system since the 1960s, and during the difficult financial period in the 1990s, the struggle was to maintain (not to reduce or abolish) existing standards. In Germany, the concern seems mostly to be directed toward retaining the status quo rather than to introduce any major innovation; in fact the struggle is reminiscent of what happened in Sweden some forty years ago, particularly as regards the struggle for a change in mentality.

The Woman-friendly Swedish Political Culture

It is important to realize that the differences in fertility impacts are not solely the product of single items in the battery of family policies, or even groups of such items. The Swedish situation is characterized by a political culture essentially different from what one experiences in Germany, particularly in West Germany. Here are some features that justify an assessment of the Swedish political culture as much more woman-friendly than the German culture: – As we have mentioned already, the unit toward which policies are directed is the individual in Sweden and the married couple in Germany. This is highlighted by their contrasting systems of income tax and social security. In Sweden, each individual is taxed for his or her income and has his or her own social-security coverage.

In Germany, the family is taxed for the joint income of its members and the social-security unit is again the married couple. Sweden has a forceful drive toward **gender equality** in every area of private and public life, including education and the labor market. It is hard to see that Germany is anywhere near as interested in such aspects. In Sweden, considerations concerning gender-equality and social justice have guided reforms in family (and other) policies. The reforms have not had an explicit pro-natalist motivation beyond a desire to enable everyone to have the children they want. – Sweden has a decidedly more flexible educational system (for adults). Women (and men) may return to take more education after a break, perhaps after the arrival of a child. This means that the arrival of a child does not have to imply the end of educational attainment. In a less flexible system, young women may be discouraged from childbearing because they fear that once their educational enrollment is interrupted it may be impossible to continue their studies. – The Swedish system has a clear child-oriented perspective.

It is **child-friendly** by being woman-friendly. It emphasizes the “equal right of working women to also have children” instead of “the right of mothers to have employment” (a formulation due to Alva Myrdal). The attitude to full-time schooling, a practice that probably greatly influences a woman’s possibility of combining motherhood and job. The federal government has reserved large sums of money to expand full-time schooling.

However, in Germany the Bundesländer are responsible for organizing public education. In the end, some conservative Bundesländer did not use the money they were offered because they had political objections to full-time schooling. The Swedish system puts great store on regarding day-care as a pedagogical opportunity and the whole system as a tool toward promoting equal opportunities for all children, not as a means of guarding children while their mothers are at work. Attempts at restricting daycare to save money have met with strong resistance in the population. Swedish policies encourage both-parent participation in childrearing. For instance, each parent must take two of the thirteen paid months of parental leave, as we have noted already. The strongest criticism now heard in Sweden is that men do not participate enough on the home front.

Population Policy in Russia

Population aging is a global trend, and Russia is no exception. According to the World Economic Forum (2011), the share of people over 60 in the global population has risen from about 8 percent in 1950 to 11 percent and is expected to reach 22 percent by 2050. In Russia, this share had already reached 19 percent by 2013, up from 15 percent in 1989. A population is considered to be relatively old when the share over 65 is more than 8–10 percent. In 2013, this share in Russia constituted about 13 percent of the total Russian population, a 35 percent increase from 9.6 percent in 1989. The share has been quite stable for the last decade, but Rosstat projects that it will reach about 19 percent by 2031.

While population aging reflects in part a significant achievement in terms of increased longevity, it can cause problems for economic development and put a strain on social insurance systems. Longer life expectancy is a cause for celebration, especially after precipitous falls in this indicator during Russia’s transition period in the 1990s. Still, as discussed in the companion study on active aging (Levin 2015), population aging everywhere raises concerns about the sustainability of economic development as some societies experience both aging and shrinking working-age population, causing increased burdens on financial and healthcare systems. Many countries, Russia among them, still rely heavily on pay-as-you-go pension systems that use social security contributions of current workers to fund pensions for retirees. Deterioration of dependency ratios—the number of working people per pensioner—calls into question the fiscal sustainability of such systems. The statutory retirement age for old-age labor pensions in Russia is relatively low (60 for men and 55 for women), which makes the situation even more troubling.

Policymakers in many countries, including Russia, use pro-natalist policies to stimulate fertility and thus slow the aging of the population. Two main factors can contribute to population aging:

- (1) a decrease in the number of children (lower fertility) and
- (2) an increase in the number of elderly (higher longevity).

As life expectancy in Russia continues to rise, the pace of population aging will intensify and pro-natalist policies may become increasingly attractive. Many countries, like Russia, already have in place policy instruments to support childbearing. One of the most widely used measures is higher

payments during maternity leave and an extended duration of the leave. Currently across Europe maternity leave ranges from 90 days in Iceland to 410 days in Bulgaria; some countries provide full compensation for the mother's pre-maternity earnings while others (such as Ireland, the United Kingdom, and Slovakia) provide a share of such earnings or a flat-rate benefit. Other common policy measures are cash transfers (paid either one time at birth or regularly during parental leave), tax deductions, and housing allowances.

The effectiveness of pro-natalist policies in stimulating fertility and in slowing population aging can be disputed. (1) There is a significant lag between when a child is born and when that child enters the labour force; thus, even if successful today's pro-natalist policies will not have an effect on economic output for at least two decades. Immigration policy can provide a more immediate payoff in terms of compensating for an aging workforce and thus improve the domestic demographic situation. However, immigration has its own challenges. It can only postpone the impacts of population aging because more and more immigrants would be needed to sustain economic growth. (2) There is no consensus in studies of family policies about whether family policies are effective in raising fertility.

While some have shown that child-related cash transfers stimulate childbearing by reducing the associated costs, others have demonstrated that birth-related payments do not seem to be effective at raising birth rates. Significant increases in parental leave, as in Austria in 1990, can stimulate fertility, but they can also have unintended consequences, such as drawing women out of the labour force for extended periods, or even indefinitely. Rather than specific single measures, what seems to matter more for reproductive behaviour is a combination of family-friendly policy measures, with the most promising directed to making motherhood and participation in the formal labour force more compatible. This study examines current pro-natalist policies in Russia and suggests policy options to help make them more effective. Since 2007, Russia has been among the countries with the most active family policies, aimed at raising the proportion of families with two and more children.

Fertility Trends in Contemporary Russia

Though Russia's population has been declining since 1992, the decline may now be over. Between 1992 and 2012, the population fell by about 5.2 million people. The nadir of births was reached in 1999, when 1.22 million children were born, and deaths peaked in 2003, when 2.37 million people died. According to the United Nations Population Division, the rate of Russia's natural increase in population in 1990–2005 was among the lowest in the world—higher only than in Bulgaria, Latvia, and Ukraine. Unlike other countries in the region, migration to Russia, mainly from Central Asia, has been partly compensating for the precipitous natural decrease in population. In 2013, for the first time since 1991, Russia recorded a natural, though small, increase in its population (by 22,900 people). Population size and structure, as well as fertility rates, vary considerably from region to region in the Russian Federation. The North Caucasus, Tatarstan, and Yakutia have had sustained natural population growth; meanwhile, in some areas of Northwest Russia and the Central Federal Okrug, the death rate exceeds the birth rate by more than 50 percent.

In 2013, in half of Russia's regions (40, including two capitals, which together account for 56 per cent of Russia's population) the number of births registered exceeded the number of deaths; in the other 40 regions, the opposite was the case. Such variability can be explained by cultural differences (larger families in regions with Muslim-majority populations); economic differences (the richest city, Moscow, saw its population increase); environmental differences; and differences in the level of

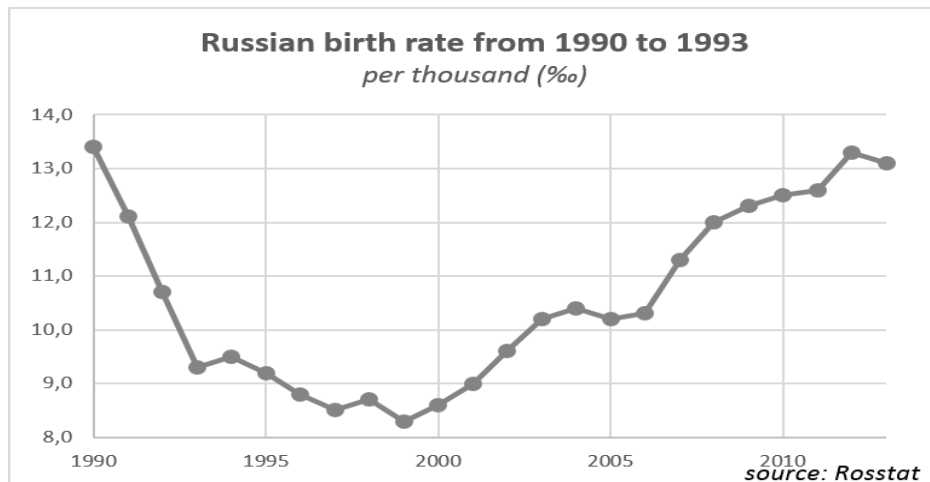
regional support to families with children. Fertility patterns have been changing over time, and these dynamics reverberate in the age structure of today's population. Russia has seen several waves of demographic transformation. The first significant drop in the number of newborns in the 1960s (see Figure 1) was caused by two factors: (1) the 1955 abolition of the abortion ban, which had been in place since 1936, and more importantly, (2) the "war echo": there were smaller cohorts of women in the most reproductive age group (20–29 years) because fewer children were born during World War II.

Total fertility rates also started to decline, falling from 2.5 in 1960 to about 2 by the end of the 1960s. Family support measures introduced in the early 1980s were associated with a rise in both number of births and total fertility rate, which reached 2.2 in 1987. The social and economic hardship of the 1990s resulting from the collapse of the Soviet Union reversed the positive fertility trends of the 1980s. The breakup of the Soviet Union and subsequent major social and economic transformation in Russia, with poverty and inequality both rising, changed the demographic landscape one more time. All fertility indicators declined in the 1990s, with the total fertility rate bottoming out at 1.16 in 1999. Births declined by more than 60 percent, especially among mothers aged 25 or less. Another major phenomenon observed in the 1990s was the almost doubling of extramarital births and a decline in the number of abortions by about 80 percent due to greater availability of modern contraceptives.

Starting in 2000, economic stabilization and recovery of some postponed births led to a rise in fertility. As the economic decline, hyperinflation, and instability of the 1990s faded into history, more and more women born in the mid-1960s or the 1970s who had reached their early 30s and late 20s could afford to become mothers for the first or second time.² The fertility rate increased for all women aged 25 and older, with the largest increase among women over 30. As a result, the mean age at birth went up from 25.6 years in 1999 to 26.6 in 2006. Postponement of childbearing in Russia started with the mid-1960s cohort and continued thereafter. For example, while the cumulative cohort fertility rate (CCFR)³ for women born in 1964 who had children when they were 15–25 was 1.17 births, the CCFR for women born in 1982 who had children at 15–25 was just 0.7.

New government policies to encourage larger families took effect in 2007. Though there were more births, fertility rates were still below the replacement rate of 2. In 2006 the total fertility rate was 1.31—not much higher than its historic minimum of 1.16 in 1999. Low fertility coupled with high death rates led the number of Russians to fall, which attracted the attention of the federal government. The Duma ratified policies to support families with children at the end of 2006; their focus was on stimulating second and higher-order births, with child-related income transfers to mothers or other caregivers becoming differentiated by child's birth order. The policies are discussed in detail below.

Fertility has risen significantly since the family policy package was introduced. Five years after the new measures became operational, the number of births had risen from less than 1.5 million in 2006 to more than 1.9 million in 2012, and the total fertility rate went up by more than 30 percent, from 1.31 to 1.69. The largest increase was recorded in the first two years after the new family policy measures were introduced; in 2007 the rate was up by 8.5 percent and in 2008 by 6.1 percent. Women over 30 having the second or third child contributed most to rising fertility rates, suggesting that the policies achieved their objective. Today, however, as will be discussed later, the effect of the measures seems to be fading out.



8.2 Anti-Natalist Population Policies

The aim of anti-natalist policies is to decrease the total fertility rate, as well as the crude birth rate, in order to slow the population growth. It encourages families to have fewer children. It is also termed as restrictive population policy.

Human consumption is depleting the Earth's natural resources impairing the capacity of life-supporting ecosystems. Human beings have changed ecosystems more rapidly and extensively over the past 50 years than during any other period, primarily to meet increasing demands for food, fresh water, timber, fibre and fuel. Such consumption, together with world population increasing from 2.6 billion in 1950 to 6.8 billion in 2009, are the major contributors to environmental damage.

Besides these, high rate of population growth is one of the causes of widespread poverty, under-nutrition, immature death, large scale infant mortality rate, maternal death, unemployment, food scarcity, poor health etc. Therefore, restriction of population growth is of urgent necessity.



Plate: Anti-natal Policy of Thailand
Source: Accessed from
<https://www.youtube.com/watch?v=UmZcAu541PQ>

The significance of unintended and unwanted pregnancies for population growth can be seen in the high proportion of pregnancies that are unplanned each year: out of 210 million pregnancies worldwide, 80 million (38%) are unplanned, and 42 million (20% of all pregnancies) end in abortion. Reducing unintended pregnancy is the factor in continued population growth that is most amenable to programme and policy intervention.

Organized family-planning programmes have a 40-year track record of success in helping hundreds of millions of couples choose the number and timing of their pregnancies.

Example – The famous 'one-child policy' in China, introduced in 1978-1980. In this policy women were forced to have only one child, otherwise they would be punished by the law. These punishments could be fees or less governmental support and in some cases even forced sterilization. On the other hand the government introduced incentives to persuade adults to adhere to the rules. The influence of this policy is remarkable – it is estimated, that without these family planning policies there would be 400 million more Chinese people today and clearly the crude birth rate decreased a lot.

9.0 Comparative study of population policies between India and China

Both India and China hold anti-natal population policies.

9.1 China's One Child Policy

a) Why was China's One Child Policy introduced?

The first modern census in China in 1953 showed that the population was at 583 million people. In 50 years', the population had more than doubled to 1252.8 million people in 1999. The average family had three children, and the population didn't seem to be slowing. The government was concerned that a rapidly growing population would put pressure on resources, so during the 1970s, tried to encourage family planning and delayed marriage.

b) How was the policy implemented?

If a couple have only one child, they could receive a 5-10% salary bonus, but having two would result in a 10% salary reduction. Having only one child meant that the family would get priority in housing, education and health care. Couples also got higher pensions on retirement for having only one child.



China's One Child Policy

9.1.1 Successes of China's One Child Policy

- The total fertility rate has fallen from nearly 6 to about 1.7
- Population growth rate has fallen from a peak of 2.61% in the late 1960's to about 0.65% today
- Birth rates have fallen from highs of 45 to about 13 today.
- The availability of contraception has increased
- Up to 250 million births have been prevented since 1979
- China's population should peak in the first half of the 2030's (however, it might be as much as 1.45 billion)

China's family planning policy has prevented 400 million births. This policy is a success as this added amount in China today would cause a serious strain on resources. However, the policy has severely changed the traditional Chinese family, from having many children to only one. There are still many Chinese people who do not and will not agree to only having one child, but overall, the policy has been very successful in stabilizing China's population.

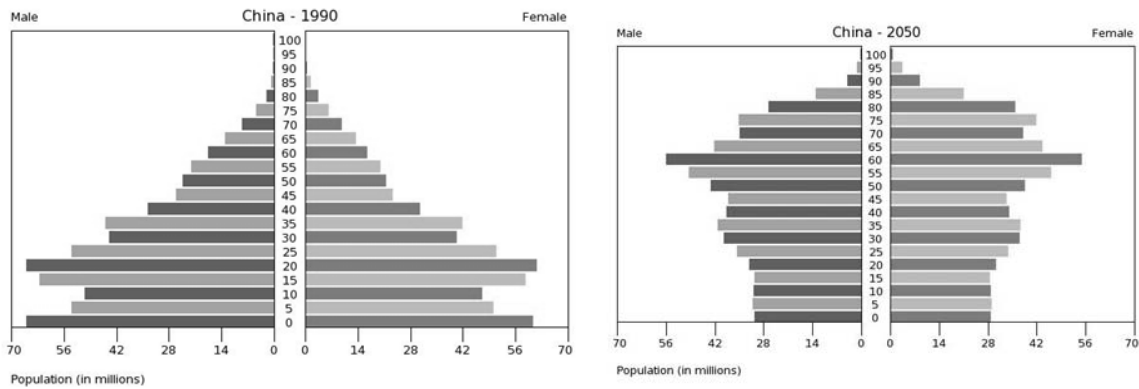


Figure 24: China's Age-Sex Pyramid – a) in 1990, b) in 2050 – An Expected Effect of Anti-natal Policy
Source: Accessed from <https://zisgeography.wordpress.com/2010/10/05/anti-natalist-policies/>

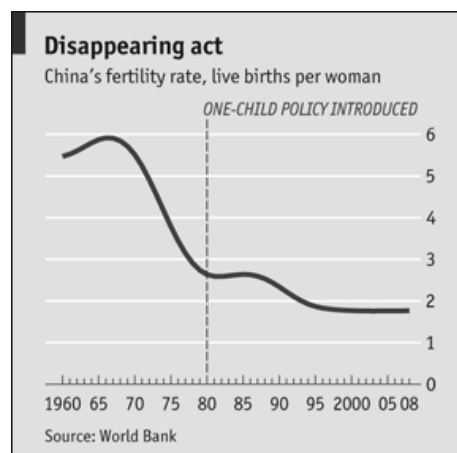


Figure 25: Declining Fertility Rate in China
Source: Mindomo

9.1.2 Failures of China's One Child Policy

- There have been criticisms about human rights, not only over freedom of choice, but forced abortions and sterilisations.
- Female infanticide has taken place, where the boys have been favoured.
- There is now a sex imbalance in China (117:100).
- Many children have been abandoned for adoption.
- There is an ageing population and an increased dependency ratio.
- There has been shortage of workers in some areas.
- The so called 'little emperors' syndrome where only children are spoilt.

The penalties for having more than one child were very severe and many have criticized the One Child Policy for its claimed abuses of human rights. There have been many reports of the use of ultrasound foetus sex determination and selective terminations, as boys are still seen to be of more value than girls, especially in rural areas of China. Female infanticide has also been common, as well as child trading and infant abandonment. Many of the family planning providers have been accused, following the birth of the first child, of forcing both late terminations and sterilization.

Due to female infanticide, the number of men is thought to outnumber women in China by more than 60 million, which means that by 2020, there may be 30 million men of marriageable age who will not be able to find a wife. This will cause major problems for the population. Because couples acknowledge that they will only have one child; they aim to bring them up in the best possible way, leading to many young boys being classed as 'Little Emperors' as they are spoilt by their parents. China now has an increasingly ageing population, which means that the elderly need to be provided for, for longer. With only one child to support both elderly parents, this is going to cause financial problems.

China calls for halt to slaughter of baby girls

by JONATHAN MIRSKY

CHINESE peasants are allowing their baby girls to die at such a rate that a call has gone out to save them.

Nothing but murder or deliberate neglect can explain why in some communes just 200 girls survive out of every 500 children born, although China's 1982 census shows that the number of girl babies at birth is only marginally less than boys.

These figures reported in *China Youth Daily*, highlight the resurgence of female infanticide, usually by abandonment or 'exposure' but sometimes by drowning. It is another of China's traditional practices, such as prostitution and arranged marriage, once claimed to have disappeared under communism.

Baby killing has remained common enough for the 1980 Marriage Law to forbid it. 'Infanticide by drowning and any other acts causing serious harm to infants are prohibited,' the law states. Now *China Youth Daily* insists: 'These inhuman and brutal acts should not be tolerated.'

The rise in the killing of girls is a direct result of China's one-child family drive, which seeks dramatically to reduce the population

of more than one billion. Although an extensive birth control campaign has not prevented a rise in population, Peking still shrinks from a national population control law, probably fearing the kind of public disorder which brought down Mrs Gandhi's previous government in India.

At provincial level, rewards, punishments, and mass mobilisation are being used to persuade newly-weds to limit themselves to one child.

Little girls, like pandas, are therefore becoming an endangered species as the increasingly draconian population campaigns bring lingering Chinese prejudices

against females to the surface. In 1981 Deng Yingchao, the widow of Premier Chou En-lai and China's most honoured woman, attacked the 'feudal' idea that women are inferior.

Early this year a Central Committee member admitted to the All-China Women's Federation that women are still cursed and beaten by their husbands and mothers-in-law for bearing girl babies. Drowning girl babies often occurs, he said.

Many Chinese still believe that without a son there can be no descendants. Only male children hand down the family name and can worship and nourish their ancestors.

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9.2 India's Anti-Natal Population Policy

Since the middle of the 20th century, developing countries including India have been facing the problem of unsustainable population growth that had placed a lot of pressure on their development pattern and prosperity.

9.2.1 Before the Independence

Radha Kamal Mukherjee Committee, 1940 In 1940

The Indian National Congress had appointed a committee on population under the leadership of renowned social scientist Radha Kamal Mukherjee to come up with suggestions to arrest increasing population of the country. The committee after deliberations suggested that population can be controlled by placing emphasis on self-control; creating awareness about the cheap and safe methods of birth control; opening birth control clinics; increasing the age of marriage; discouraging polygamy etc.

Bhore Committee, 1943

The Government of India in 1943 appointed a Health Survey and Development committee under the chairmanship of Sir Joseph Bhore. This committee had suggested 'deliberate limitation of family' approach as a way for controlling population, which cannot be achieved through self-control 'to any material extent'.

9.2.2 After the Independence

In 1951, India became the first among the developing countries to come up with a state sponsored family planning programme. The Planning Commission which was set up in 1950 was given the task to decide upon the contours of the family planning programme.

In 1952, a population policy committee was constituted. This committee had recommended setting up of a Family Planning Research and Programmes Committee. But the policies framed in 1951-52 were ad-hoc in nature and was primarily based on self-control. So it was not successful.

Subsequently, in 1956, a Central Family Planning Board was established. This board focussed much on sterilization. However, until 1960s a concrete policy on population control was not adopted and the government was vacillating as to what would be the best approach **First Five Year Plan (1951-56)**

The following were stipulated by the first five year plan for population control:

- To collect information about accurate factors which were contributing to the rapid growth of population
- Work out suitable techniques of family planning and chalk out appropriate strategies to create awareness about these strategies among people.
- Make public health agencies to advise people on family planning as an integral part of their service.

Second Five Year Plan (1956-61)

In the second plan, the number of family planning clinics was increased significantly. But since these clinics were largely set up in urban areas, it did not attract many clients. Until the fifth Five Year Plan, the planning was mostly concerned with 'birth control' and 'family planning'.

Fifth Five Year Plan (1974-1979)

In the fifth five year plan, 'maternal and child health and nutrition services' were included as a part of the population control programme.

National Population Policy 1976 and 1977

In 1976, the government of India came up with its first National Population policy. The policy came up with a number of measures to arrest the population growth.

- Increasing the minimum legal age of marriage for girls and boys to 18 and 21 respectively
- Monetary incentives for birth control
- Improving the literacy levels of females both through the formal and non-formal channels
- Population was made as a factor for sharing central resources with that of the states. Linking 8% of the central assistance to the State Plans by weighing the performance of the states in the family welfare programmes.
- Popularise family welfare programmes by using all forms of media
- Inculcating population education into the formal education system
- The National Population Policy, 1976 was completely different from the earlier policies. It was hitherto believed that development and education would themselves restrict the rate of population growth, while the government's own programme was restricted to family planning, by way of motivating people to accept family planning and providing clinical facilities and other services to its acceptors. But the 1976 policy noted that – *To wait for education and economic development to bring out a drop in fertility is not a practical solution.* The very increase in population makes economic development slow and more difficult to achieve. The time factor is so pressing, and the population growth so formidable, that we have to get out of the vicious circle through a direct assault upon this problem as a national commitment.”
- During the Emergency period (1975-77), coercion and pressure were used in implementing the family planning programme. The Central assistance of 8 per cent was linked with the family planning performance. For the first time the Union government allowed some states to initiate legislation for compulsory sterilisation. The policies, however, discredited the entire family planning programme, and the experiment of the government to implement the so-called bold measures for lowering the birth rate in a relatively short period ended in a fiasco. In 1977, the new government ruled out the use of force and coercion, and the family planning programme was renamed as the ‘family welfare programme’.

National Population Policy, 2000

As per the latest World Population Prospects released by United Nations (revision 2015), the estimated population of India will be 1419 million approximately whereas China's population will be approximately 1409 million, by 2022. In spite of the perceptible decline in Total Fertility Rate (TFR) from 3.6 in 1991 to 2.3 in 2013, India is yet to achieve replacement level of 2.1. Twenty four states/UTs have already achieved replacement level of TFR by 2013, while states like UP and Bihar with large population base still have TFR of 3.1 and 3.4 respectively. The other states like Jharkhand (TFR 2.7), Rajasthan (TFR 2.8), Madhya Pradesh (TFR 2.9), and Chhattisgarh (TFR 2.6) continue to have higher levels of fertility and contribute to the growth of population.

The National Population Policy 2000 is uniformly applicable to the whole country. In pursuance of this policy, Government has taken a number of measures under Family Planning

Programme and as a result, Population Growth Rate in India has reduced substantially which is evident from the following:-

- i. The percentage decadal growth rate of the country has declined significantly from 21.5% for the period 1991-2001 to 17.7% during 2001-2011.
- ii. Total Fertility Rate (TFR) was 3.2 at the time when National Population Policy, 2000 was adopted and the same has declined to 2.3 as per Sample registration Survey (SRS) 2013 conducted by the Registrar General of India.

As the existing NPP-2000 is uniformly applicable to all irrespective of religions and communities etc., therefore no proposal is under consideration of the Government to formulate new uniform population policy. The steps taken by the Government under various measures/programme are given below:-

Steps/Measures to Control the Population Growth of India by the Government of India

On-going interventions:

- More emphasis on Spacing methods like IUCD.
- Availability of Fixed Day Static Services at all facilities.
- A rational human resource development plan is in place for provision of IUCD, minilap and NSV to empower the facilities (DH, CHC, PHC, SHC) with at least one provider each for each of the services and Sub Centres with ANMs trained in IUD insertion.
- Quality care in Family Planning services by establishing Quality Assurance Committees at state and district levels.
- Improving contraceptives supply management up to peripheral facilities.
- Demand generation activities in the form of display of posters, billboards and other audio and video materials in the various facilities.
- National Family Planning Indemnity Scheme' (NFPIS) under which clients are insured in the eventualities of deaths, complications and failures following sterilization and the providers/ accredited institutions are indemnified against litigations in those eventualities.
- Compensation scheme for sterilization acceptors - under the scheme MoHFW provides compensation for loss of wages to the beneficiary and also to the service provider (& team) for conducting sterilisations.
- Increasing male participation and promotion of Non Scalpel Vasectomy.
- Emphasis on Miniap Tubectomy services because of its logistical simplicity and requirement of only MBBS doctors and not post graduate gynaecologists/ surgeons.
- Accreditation of more private/NGO facilities to increase the provider base for family planning services under PPP.
- Strong political will and advocacy at the highest level, especially, in States with high fertility rates.

New Interventions under Family Planning Programme

- o Scheme for Home delivery of contraceptives by ASHAs at doorstep of beneficiaries: The govt. has launched a scheme to utilize the services of ASHA to deliver contraceptives at the doorstep of beneficiaries.
- o Scheme for ASHAs to ensure spacing in births: The scheme is operational from 16th May, 2012, under this scheme, services of ASHAs to be utilised for counselling newly married couples to ensure delay of 2 years in birth after marriage and couples with 1 child to have spacing of 3 years after the birth of 1st child. ASHAs are to be paid the following incentives under the scheme:-
 - a. Rs. 500/- to ASHA for ensuring spacing of 2 years after marriage.
 - b. Rs. 500/- to ASHA for ensuring spacing of 3 years after the birth of 1st child.
 - c. Rs. 1000/- in case the couple opts for a permanent limiting method up to 2 children only. The scheme is being implemented in 18 States of the country (8 EAG, 8 NE Gujarat and Haryana).
- 3. Boost to spacing methods by introduction of new method PPIUCD (Post-Partum Intra Uterine Contraceptives Device).
- 4. Introduction of the new device Cu IUCD 375, which is effective for 5 years.
- 5. Emphasis on Postpartum Family Planning (PPFP) services with introduction of PPIUCD and promotion of minilap as the main mode of providing sterilisation in the form of post-partum sterilisation to capitalise on the huge cases coming in for institutional delivery under JSY.
- 6. Compensation for sterilisation acceptors has been enhanced for 11 High Focus States with high TFR.
- 7. Compensation scheme for PPIUCD under which the service provider as well as the ASHAs who escorts the clients to the health facility for facilitating the IUCD insertion are compensated.
- 8. Scheme for provision of pregnancy testing kits at the sub-centres as well as in the drug kit of the ASHAs for use in the communities to facilitate the early detection and decision making for the outcome of pregnancy.
- 9. RMNCH Counsellors (Reproductive Maternal New Born and Child Health) availability at the high case facilities to ensure counselling of the clients visiting the facilities.
- 10. Celebration of World Population Day 11th July & Fortnight: The event is observed over a month long period, split into fortnight of mobilization/sensitization followed by a fortnight of assured family planning service delivery and has been made a mandatory activity from 2012-13 and starts from 27th June each year.
- 11. FP 2020- Family Planning Division is working on the national and state wise action plans so as to achieve FP 2020 goals. The key commitments of FP 2020 are as under :
 - o Increasing financial commitment on Family Planning whereby India commits an allocation of 2 billion USD from 2012 to 2020.
 - o Ensuring access to family planning services to 48 million (4.8 crore) additional women by 2020 (40% of the total FP 2020 goal).

- o Sustaining the coverage of 100 million (10 crore) women currently using contraceptives.

Reducing the unmet need by an improved access to voluntary family planning services, supplies and information. In addition to above, Jansankhya Sthirata Kosh/National Population Stabilization Fund has adopted the following strategies as a population control measure:-

Prerna Strategy: JSK has launched this strategy for helping to push up the age of marriage of girls and delay in first child and spacing in second child the birth of children in the interest of health of young mothers and infants. The couple who adopt this strategy awarded suitably. This helps to change the mindsets of the community.

Santushti Strategy: Under this strategy, Jansankhya Sthirata Kosh, invites private sector gynaecologists and vasectomy surgeons to conduct sterilization operations in Public Private Partnership mode. The private hospitals/nursing home who achieved target to 10 or more are suitably awarded as per strategy.

National Helpline: JSK also running a call centers for providing free advice on reproductive health, family planning, maternal health and child health etc.

Advocacy & IEC activities: JSK as a part of its awareness and advocacy efforts on population stabilization, has established networks and partnerships with other ministries, development partners, private sectors, corporate and professional bodies for spreading its activities through electronic media, print media, workshop, walkathon, and other multi-level activities etc. at the national, state, district and block level.

Between 1981 and 1991, the annual rate of population growth was estimated at about 2% in India. The crude birth rate in 1992 was 30 per 1000, only a small change over the 1981 level of 34 per 1000, after the family planning scheme had been initiated. This shows how China's population policy was a lot more efficient than India's. India's government became too fixated on sterilizations, so this began to put many people off and people began to ignore the family planning service. China's was more effective mainly due to their forced sterilizations and use of punishments if a couple had more than one child.



a) Why did India's policy fail to reduce birth rates?

Too much propaganda is being told what to do lead the people of India to turn against the scheme. It was also difficult to change their traditions, as usually, large families are normal. Not enough

awareness in the more rural areas also meant that it was harder for these people to hear about the family planning schemes.

b) Kerala Success- what were the main objectives of the successful policy in Kerala state?

Kerala has the highest literacy rate in India, 91%, which is a lot higher than the average of only 65%. Along with this, its growing service economy means that it is often quoted as indicative of a middle class society. In Kerala, many couples have had their children in quick succession, do not use any spacing methods and then opt for sterilization. The National Population Policy has seen success here with female empowerment and a majority of married women choosing to use contraception. Because of the high literacy rate, most people are educated, so would prefer to have a career and wait for children, which is why the family planning scheme has worked so well here.

Table 3: Comparative Analysis of Population Policies between China and India

China	India
Later age for marriage- 25 for women, 28 for men	age for marriage- 18 for women, 21 for men
Couples having to apply for the right to start a family	No such rule
A 5-10% salary bonus for limiting to one child	No such rule
A 10% salary reduction for having two children	No such rule
Priority in housing, education and health care for only one children	Availability of maternity leave for only the first two children
No extra space allocation for second or third child	Increasing the awareness and availability of family planning and contraception
Higher pensions on retirement for limiting to one child	No such rule
Retirement benefits for smaller families	No such rule

10.0 Conclusion

This self-learning material has explained different population related facts and figures. It shows the current demographic situations at different parts of the world. It also explains the causes of the differences lying behind these. Besides, a number of theories such as Malthusian theory, Limits to Growth, Demographic Transition Theory etc. have also been presented with their present day applicability. Thus it has enabled the readers to have a base level knowledge of population geography.

11.0 Self-Assessment Tests

- 1) Write the scope and content of Population Geography.
- 2) How will you differentiate Population Geography from Demography?
- 3) What are the major sources of population data in India? Briefly describe the nature data harnessed from these sources.

- 4) Define fertility, fecundity, mortality, morbidity.
- 5) Explain the factors controlling population growth.
- 6) What is meant by infant mortality rate?
- 7) What does maternal mortality rate represent?
- 8) What do you mean by juvenile population?
- 9) What is dependency ratio?
- 10) What is migration? Explain the factors of migration.
- 11) Explain the demographic transition model with suitable examples.
- 12) What is the essence of Malthusian theory of population growth?
- 13) What are the differences between pro-natal and anti-natal population policies?
- 14) Compare the population policies of India and China.
- 15) Write a short note on India's National Population Policy 2000.
- 16) Write in short the success and failures of China's one child policy.
- 17) What do you mean by 'three or more' policy?

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Disclaimer

This self-learning material is based on different books, journals and web-sources.

GROUP – GEO206T.2: SETTLEMENT GEOGRAPHY

(Credit – 2; Marks - 50: Internal Evaluation – 10 + Semester-end Examination - 40)

1.0 Introduction

The basic objective of the discipline of Geography is to analyse the surface features on the earth's surface. Geography has paid attention on physical features of the earth's surface since a long time. However, besides the physical attributes, the cultural or the anthropogenic features also draw equal attention. The study of settlement geography is comparatively new. The origin and growth of settlements, their morphology, hierarchical distribution within a system etc. are the major focus of this sub-discipline. There are two major types of settlements in the world – rural and urban. Emphasis has been paid more on urban geography than rural geography. In a number of universities in India and abroad, urban geography is taught as specialization.

1.1 Learning Objectives

After studying this unit, the learners will be able to

- Conceptualize ekistics and settlement,
- Analyse the theories and models of settlement,
- Interpret the rank-size rule,
- Analyse the concept of primate city
- Differentiate between the rank-size rule and primate city model
- Know the central place theory
- Describe the different types and patterns of settlements
- Define an Indian settlement to be urban,
- Conceptualize different terms related to urban geography, such as million cities, mega cities, megalopolis, ecumenopolis, urban sprawl, urban renewal and rural-urban continuum

1.2 Assessment of Prior Knowledge

To assess students' prior knowledge, they may be asked

- What is a settlement?
- How settlements are formed?
- Why do we need to study settlement geography?
- Have you found any noticeable difference between town and village?

1.3 Learning Activities

For their successful learning programme, they may be assigned to prepare the thematic map of degree of urbanisation of West Bengal and of India based on latest census data. They can also be assigned to bring out different types and patterns of settlement from topographical sheets.

1.4 Feedback of Learning Activities

Feedback of learning activities may be obtained through question-answering, project, group discussion, quiz on settlement geography etc.

2.0 Concept of Ekistics

The term ekistics was originally coined by C.A. Doxiadis to refer to the science of human settlements. It avoids the specific terms of village, town, metropolis etc. and thus all sorts of human settlements are brought together under the single umbrella of ekistics. A settlement is generally defined as an area on the earth's surface where groups of people inhabit more or less permanently with the intention of habitation and socio-economic purposes. We can identify it as hamlets, villages or cities. Now, one may question that many tourists stay in hotels. Are these hotels settlements or not? Certainly, these are not settlements because these are not having permanency in character. However, depending on the jobs of these hotels, many local people start residing around these tourist spots. These local people's residences may be called settlements. Therefore, three basic criteria of a settlement is habitation, permanency and interaction.

Settlements develop with the purpose of either habitation and or socio-economic interaction. These sorts of interaction are expressed through housing material, building plan, settlement size, its location and through settlers' economy. Generally, rural people are dependent on agriculture and allied activities, and urban people are dependent on non-agricultural activities.

We cannot acquire proper knowledge about our villages, towns and cities unless we manage to see the whole range of the man-made systems within which we live, from the most primitive to the most developed ones - that is, the whole range of human settlements. This is as necessary as an understanding of animals is general is to an understanding of mammals - perhaps even more so. Our subject, the whole range of human settlements, is a very complex system of five elements - nature, man, society, shells (that is, buildings), and networks. It is a system of natural, social, and man-made elements which can be seen in many ways - economic, social, political, technological, and cultural. For this reason only the widest possible view can help us to understand it. There is a need for a science dealing with human settlements, because otherwise we cannot view these settlements in a reasonable way. Is such a science possible?

The answer can be given in two ways. First, by observing that, in some periods in the past, people must have had such a science, which was probably written down only in ancient Greek times (in documents by the architect and engineer Vitruvius). Otherwise, how did people create cities that we still admire? Second, we are now convinced that man, in creating his settlements, obeys general principles and laws whose validity can be demonstrated. These principles and laws are actually an extension of man's biological characteristics, and in this respect, we are dealing with biology of larger systems. It can be argued perhaps that we are dealing with a phenomenon with a ridiculously short life - some tens of thousands of years, as compared with billions of years for the phenomena of microbiology and even longer periods for the phenomena of chemistry and physics. However, there is

no way of proving that a certain period is too short, or long enough, for the development of principles and laws. In this case, it is long enough to convince us of certain truths.

2.1 Ekistics Elements

The abscissa of ekistic units remains constant in all uses of the ekistic grid, and the most usual ordinate consists of the five ekistic elements, NATURE, ANTHROPOS (MAN), SOCIETY, SHELLS (dwellings or buildings), and NETWORKS, with a sixth line denoting their SYNTHESIS.

i) NATURE, the first element, represents the ecosystem within which rural settlements must exist. It involves a number of component processes including the hydrologic cycle, bio-systems, air-sheds, climatic zones, etc. Archaeological studies show that even primitive man with limited tools made profound changes in natural systems.

Over-cultivation in the Thar Desert of the Indian subcontinent and overgrazing in the Middle East are two examples of how early cultivations weighted the natural balance and tipped it towards an uninhabitable landscape. If such significant changes in the natural system could be brought about by such limited numbers of men, it seems logical to suppose that today's 6,000 million persons must have far greater effectiveness in fouling the planet.

And, if the earth is to support 30,000 million people in the future, the interrelationships and ranges of adaptability of human settlements and natural processes must be very clearly understood and observed, for neither can survive without the other. At another level we cannot forget man's psychological and physical needs for contact with the world of nature.

ii) ANTHROPOS himself is also constantly adapting and changing. The medical profession, in its move from "barbarism" to concepts of the constitution of the healthy individual, can contribute many important inputs to the better organization of urban life. Studies have shown that certain physical and psychological diseases are directly associated with urbanization. These include obesity, respiratory ailments and alienation (anomie).

This gives rise to many questions, such as whether it is possible for mankind to adapt to a completely urban world with no rural escapes; what urban densities "are tolerable"; and how the city may be made a satisfactory environment for the growing child. Thus, just as forward-looking medical and public health schools find a need to study the city, city builders must turn to study man.

iii) SOCIETY comprises all those aspects of the urban or rural scene that are commonly dealt with by sociologists, economists and administrators: population trends, social customs, income and occupations, and the systems of urban government. One of the most urgent aspects of society seems to be the problem of the retention, or reorganization, of values inherent in independent small communities after these have become incorporated in megalopolis — in other words, the place of the neighbourhood in megalopolis.

iv) SHELLS, or the built environment, is the traditional domain of the architectural and engineering professions. Here a central problem is how mass-produced, anonymous housing can cater for the needs of very diverse individuals and family groupings. Where can man make his own mark? Where can he leave the touch of his own hand?

v) NETWORKS provide the glue for all systems of urbanization. Their changes profoundly affect urban patterns and urban scale. We have only to think of the effect of the advent of the railroad, or of piped water supplies, or of the telephone, upon the extent, the texture and the densities of human

settlements. The increasingly rapid developments of all types of networks — coupled with population pressures — have been the most potent heralds of megalopolis.

The enormous growth in the uses of energy for the communication of ideas has whetted man's appetite for participating in all sorts of things that were formerly outside his ken. The television screen has stimulated desires both to participate in new sports, such as skiing, etc., and to participate in debates — political representation, etc. To respond to man's demands, transportation, communication and utility networks must all expand even faster than the anticipated growth of settlements.

vi) SYNTHESIS arises from a consideration of the interactions of all the ekistic elements in terms of a single ekistic unit: for example, the interactions of Nature, Man, Society, Shells and Networks may be considered in terms of megalopolis. Or Synthesis can comprise a single ekistic element in terms of the whole range of ekistic units: for example, the effect of certain aspects of society (changes in the birth rate) or networks (advent of the automobile) upon all scales of human settlements.

Again synthesis can arise from synergetic associations with the total result having positive benefits greater than the individual inputs; for example, a health facilities program and air pollution control in conjunction may lead to lower mortality rates than predicted by each of the independent programs.

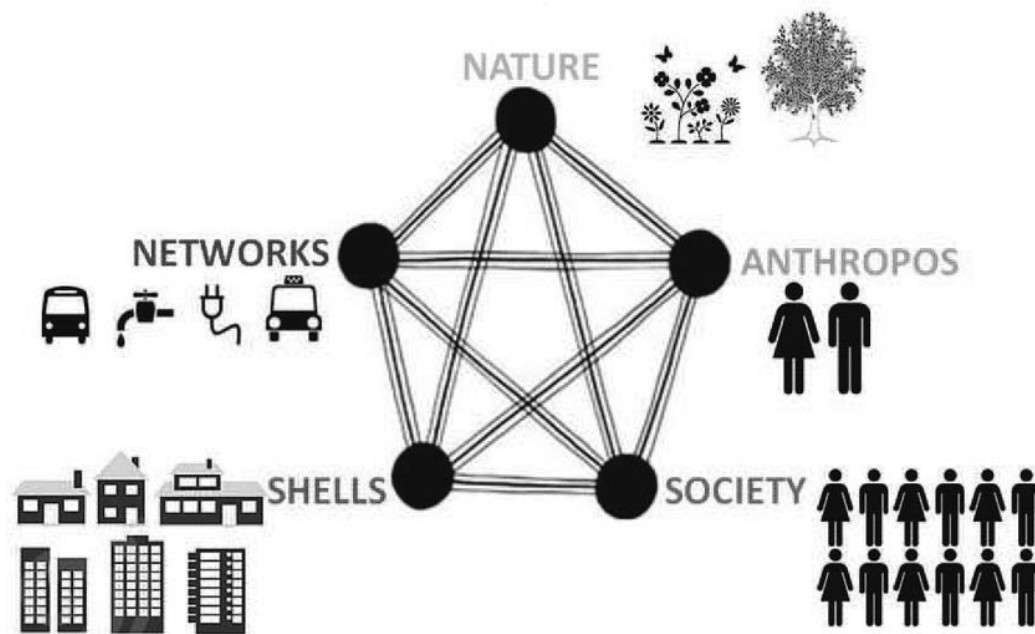


Figure 1: Five Elements of Ekistics developed by C.A. Doxiadis

3.0 Settlement Hierarchies

Hierarchy refers to the structured order. A settlement hierarchy refers to the arrangement of settlements within a given area into a certain order of importance based upon the population size of a settlement, the range and number of services provided by a settlement, and the sphere of influence or market area of a settlement. Settlements within an area vary greatly in physical size, population, and the number of services that they provide. A settlement hierarchy is when settlements are put into an order based upon their size or the services that they provide for people.

The concept of hierarchy was introduced by Walter Christaller (1933), a German Economic Geographer in his well-known Central Place Theory. The word 'Hierarchy' is not a geographical term. Hierarchy is a universal phenomenon due to variation in size and functions. The gradation and grouping the settlement centres into the size of classes is termed as hierarchy. The concept of hierarchy is fundamental to the central place theory. A character of central places to serve their respective surrounding, territory in terms of cultural, commercial and administrative requirements. Over the past 50 years, location, allocation analyses have developed a variety of models termed 'hierarchical' in that they incorporate multiple levels of either goals or facilities.

Several researchers have used 'hierarchy' to mean incorporation of a set of goals organised by priority to determine the best facility configuration for one service. Since the appearance of the central place models, a number of studies have appeared in different parts of the world. Most of the work consists simply of identification and investigations of settlement hierarchy in various areas. All hierarchical service systems involve a set of sites operating in a coordinated manner. Systems differ in the relationship between the upper and the lower service levels.

The hierarchy of settlements is the product of the centrality of settlements in a region. The centrality of a place is equal to its surplus of importance, that is, equal to the relative importance of this place in regard to region belonging to it. It is the outcome of the quality and quantity of central functions performed by a settlement. These central functions are available in few settlements but are availed by a number of settlements. The hierarchy of settlement is closely associated with the hierarchy of central functions. Hence, higher the level of functional hierarchy, higher will be the centrality of the place having that function. Identification of hierarchy of rural settlements helps in regional planning as higher order services are allocated in higher order centres and lower order services are provided in lower order centres. It serves as an essential tool in helping to ensure that new development should take place in the most sustainable locations.

In rural areas, development should be focused on settlements that can act as service centres for surrounding areas. Therefore settlement hierarchy is required in order to identify those villages that are capable of accommodating and sustaining growth, and to limit development in those smaller settlements that are not sustainable. The government should also base their rural settlement policies on the existing hierarchy of service centres as a means of reducing regional economic imbalances and distributing government services in an equitable basis.

The concept of Urban System was introduced by Brian J.L. Berry (1964) in his remarkable work "Cities as systems within systems of cities". Urban places do not exist in isolation. There is a whole series of different types of relationship between separate towns and cities and we use the term urban system to indicate that the individual urban centres are linked to each other. The urban centres play a significant role in social and economic transformation, and geographic shift of population. With the increase of population globally, towns and cities have become magnets of economic, social and political processes. „At national level cities are part of a complex system of interrelated urban places and the key elements in economic, social and political organisation of regions and nations. The interdependence among towns and cities makes it important to view a country as a system of urban places rather than as a series of independent settlements’.

Urban system is defined as any network of interdependent urban places. The nature of interdependence among urban place may be economic, political, social or cultural. In the system of cities, the changes taking place in one city such as population, economy, employment structure, etc. will have consequences on other cities in the system. The idea of urban hierarchy is central to the concept of urban system. The urban hierarchy concept considers that the urban places vary in population sizes and economic functions. The analysis of urban hierarchy mainly relates to the ranked

order of cities based on different criteria, such as population size, economic power, retail sales and number of industrial workers.

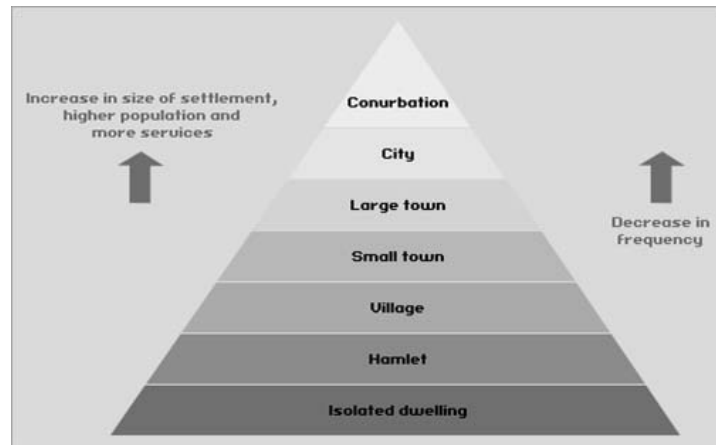


Figure 2: Settlement Hierarchies

Urban Agglomeration

1971 census defined the term “Town Group” and new term coined which is Urban Agglomeration (UA) and it refers to a continuous urban spread constituting a town and its adjoining urban outgrowths (OGs), or two or more physical contiguous towns together and any adjoining urban outgrowths of such towns. Examples of outgrowths are railway colonies, university campuses, port area, military camps etc. that may have come up near a statutory town or city but within the revenue limits of a village or villages contiguous to the town or city. For Census of India 2001, it was decided that the core town or at least one of the constituent towns of an urban agglomeration should necessarily be a statutory town and the total population of all the constituents should not be less than 20,000 (as per 1991 Census). With these two basic criteria having been met, the following are the possible different situations in which urban agglomerations could be constituted.

- i) A city or town with one or more contiguous outgrowths;
- (ii) Two or more adjoining towns with or without their outgrowths.
- (iii) A city and one or more adjoining towns with their outgrowths all of which form a continuous spread.

Out Growths (OG)

An Out Growth (OG) is a viable unit such as a village or a hamlet or an enumeration block made up of such village or hamlet and clearly identifiable in terms of its boundaries and location. Some of the examples are railway colony, university campus, port area, military camps, etc., which have come up near a statutory town outside its statutory limits but within the revenue limits of a village or villages contiguous to the town. While determining the outgrowth of a town, it has been ensured that it possesses the urban features in terms of infrastructure and amenities.

4.0 Theories and Models of Settlement Study

Settlements are studied in two ways – a) as individual settlement and b) as settlement systems. To explain the relation among different settlements of a settlement system, a number of theories and

models have been proposed. Some of these models are a-spatial and some are spatial models. Among these models, three are being discussed below:

- a) Rank-size rule,
- b) Primate city concept, and
- c) Central Place Theory

4.1 Rank-Size Rule

4.1.1 Proposition

The theory of rank-size rule demonstrates that there is a relation between the sizes of the cities and their ranks in reference to the largest city in a region. In this case, size refers to the population size. The rule states that if all the cities are arranged according to their ranks, the population of a city multiplied by its rank will be equal to the population of the largest city.

4.1.2. Proponent

This theory was originally propounded by G. K. Zipf in 1940. He made an empirical study on the 100 largest metropolitan districts of the USA. This theory is an example of inductive research.

4.1.3. Explanation of the Theory

According to this model, the largest city in a region is designated first rank and accordingly, all other cities are ordered rank-wise. Thus, at one hand, if the population of a city is multiplied by its rank, it will show the population of the largest city. On the other hand, if the population of the largest city is divided by the population of a particular city, it will show its rank. It is explained below.

$$P * pr = P$$

$$\text{Or, } pr = P/p$$

$$\text{Or, } p = P/pr$$

Where, p = Population of the particular city

pr = Rank of the p city

P = Population of the largest city

If the data of rank-size distribution of cities is plotted on a normal graph, it will produce an inverted-J shaped graph. However, if the data is plotted on logarithmic graph, it will produce a straight line graph.

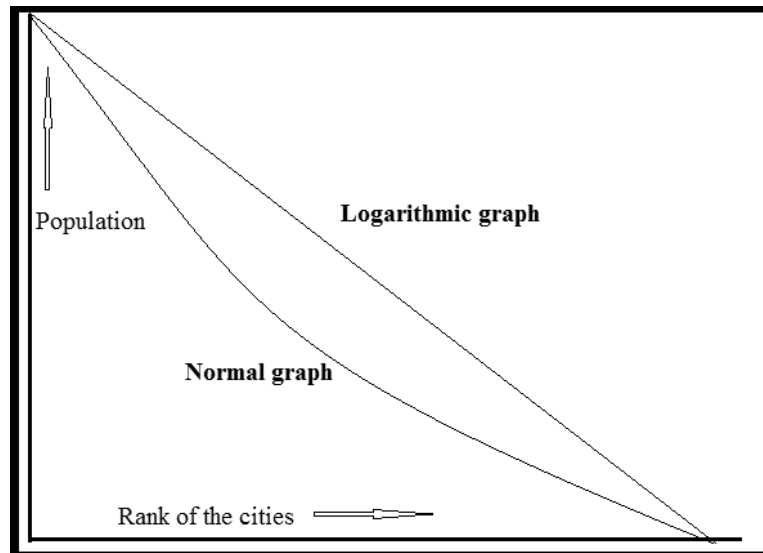


Figure 3: Rank-size Rule

4.1.4. Merits and Demerits

Zipf proposed his theory in a homogenous state of urbanization. This situation may take place when there is equity in development in a region. However, almost all the countries are characterized by uneven development pattern and the city-sizes are not equally distributed.

The theory of rank-size rule fails to explain the Indian urban scenario. Since Indian urbanization is characterized by the colonial legacy, there is maximum concentration of urban population in fewer pockets of the country. Thus the mega cities such as New Delhi, Kolkata and Mumbai are characterized by huge urban population. On the other hand, the smaller city centres are very few in number. Thus Indian urbanization is characterized by primacy not by rank-size rule.

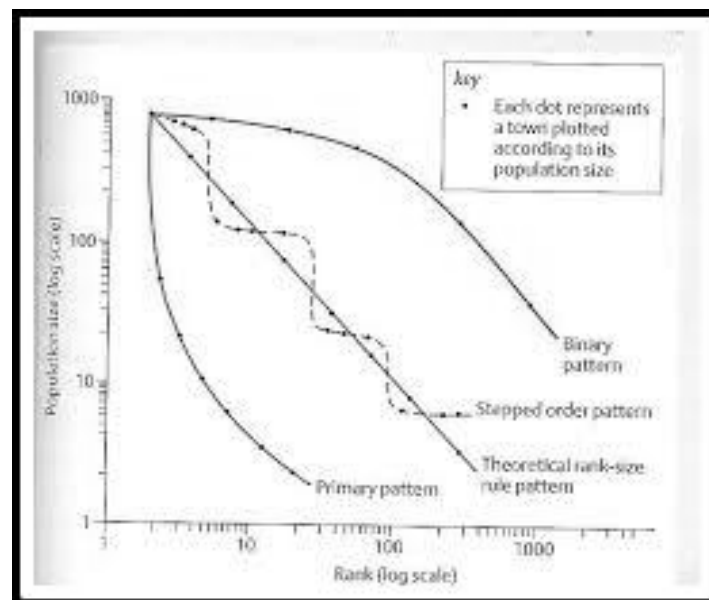


Figure 4: Rank-size Rule, Primacy and Binary Concept

Source: <https://planningtank.com/settlement-geography/rank-size-rule-by-george-zipf-1949>, accessed on August 18, 2017

4.2 Primate City Model

The concept of primate city was first formulated by Mark Jefferson in 1939. It states that the first ranking city holds the supremacy in dominating the entire region. Jefferson observed that the first ranking city was often more than double than that of the second city and five times than the third ranking city. Thus this model significantly differs from rank-size rule of Zipf. This model has following characteristics:

- Primate city is characterized by large scale concentration of people and services in such a way that all other settlements are subordinated by the significance of the primate city.
- It is like a large magnet which attracts huge mass of population. Thus the in-migration flows towards primate cities are much stronger.
- Large scale in-migration causes steady rise of population which causes concentration of diversified economic activities.
- The next order settlements i.e. the second ranking cities are much smaller in size compared to the largest city.
- These cities are not only bigger in size but they also significance in national influence. These are generally the seats of political power.
- High living standards develop in these cities.

Example: Mumbai, New Delhi, Kolkata in India; Paris in France; London in UK etc. Delhi in the Northern India is continuously rising as the primate city. It is the only city among the four largest cities whose primacy index has not declined since 1951. Delhi is the capital city of India and the central government is focusing more for the infrastructure, industrial and over all development of the city.

Rank-Size Rule and Primate City in Indian Context

The rank size model given by Zipf and the law of primate city by Jefferson helps to understand the distribution of cities and hierarchy among cities in an urban system. The perfect rank size of cities distribution in an urban system indicates economic development and an integrated urban system, whereas, the primate city size distribution indicates underdevelopment and imbalances in distribution of cities.

The distribution of cities in Indian urban system reveals that class I cities have grown at a higher rate than the small cities. The rank size distribution of cities as suggested by Zipf (1949) where the forces of unification and diversification have balanced each other, has never been achieved in Indian urban system. It indicates that the large cities are growing at a much faster rate in comparison to the small cities. It disallows the small cities to follow a log linear relationship with the large cities of Indian urban system. The rank size rule also explains the size distribution of settlements in relation to economic activities. The disequilibrium between the growth of small and large cities as explained by rank size graphs and slope values indicates dominance of large cities and the developed regions in the Indian urban system. The absence of rank size rule in the distribution of cities in Indian urban system indicates the possibility of primacy in India.

The analysis of primacy in India's urban system leads to two important facts. Primacy does not exist at national level but Indian urban system is characterised by primacy at regional level. The urban primacy at national level has not been achieved because there is more than one large and economically and politically important metropolitan cities existing in Indian urban system. The four mega cities Mumbai, Delhi, Chennai and Kolkata do not allow the concentration of urban population in one urban centre. In the post liberalisation period Pune, Hyderabad and Bangalore have emerged as other economically significant metropolises. The importance of the emerging metropolises as major IT hubs of India has resulted in the concentration of urban population in these urban centres as well. So at national level, no city in India exercises dominance over the entire nation, because, as a result of colonial history and post liberalisation, India has more than one dominant cities of national significance.

Therefore urban population is concentrated in these significant urban centres. The primacy exists at regional level as all the three regions confirmed primacy except the southern region. In Eastern region Kolkata is the classic example of primate city. Mumbai is the primate city in western region. The colonial history of India seems to be a major reason for the regional primacy. During British rule the port cities Bombay, Calcutta and Madras were the leading administrative, commercial and industrial cities. In the colonial period these three port cities made significant contribution in the maritime trade because of their geographic location. Delhi became the capital of British Indian empire in the year 1911, this resulted in the development of New Delhi. In northern region Delhi as a primate city is growing rapidly. In southern region Chennai is the largest urban centre but it was never the primate city and the relative primacy of Chennai has declined after 1981.

In this region absence of primacy is because of the rapid growth of Bangalore and Hyderabad as IT hubs. Chennai, Bangalore and Hyderabad remained the major cities of Southern region. In post-Independence period, the individual state governments are focusing on the development of their own economically important cities. This has resulted in the formation of urban primacy at state level. As argued by Jefferson (1939), the primate cities are super eminent not only in size, but also in national influence. The regional and state level primacy in India indicates the same influence of the primate city. Over a period of time these cities have become the dominant economic and political nerve centre of their state and region as well as the major destination for migrants.

4.3. Central Place Theory

4.3.1 Introduction

Central Place Theory (CPT) is an attempt to explain the spatial arrangement, size, and number of settlements. The theory was originally published in 1933 by a German geographer Walter Christaller who studied the settlement patterns in southern Germany. In the flat landscape of southern Germany Christaller noticed that towns of a certain size were roughly equidistant. By examining and defining the functions of the settlement structure and the size of the hinterland he found it possible to model the pattern of settlement locations using geometric shapes.

4.3.2 Basic Assumptions of the Theory

This theory is based on few basic pre-conditions which are stated as follows.

- The region should be an unbounded homogeneous surface.
- Population should be evenly distributed over the area.
- All settlements are equidistant and exist in a triangular lattice pattern.

- Resources are evenly distributed.
- Distance decay mechanism works.
- There is perfect competition and all sellers want to maximize their profits.

4.3.3 Explanation of Some Specific Terms Used in This Model

- **Higher order service:** Specialized services, e.g. a commercial bank
- **Lower order services:** Simple basic services, e.g. a tailor house
- **Hierarchy of settlements:** A settlement system is made up of a number of settlements which are not of equal level. There is an order in their organization. This order may be depending on size of the settlements and the complexity of functions of a settlement it serves to other areas.
- **Higher order settlements:** A settlement providing higher order services are known as higher order settlements.
- **Lower order settlements:** Settlements providing lower order services are known as lower order settlements.
- **Central Place:** A central place is a settlement which provides services to some other neighbouring settlements.
- **Sphere of Influence:** The area under influence of the Central Place
- **Threshold:** Minimum population that is required to bring about the provision of certain goods or services (Fig.)
- **Range of goods or services:** The average maximum distance people travel to purchase goods and avail the services (Fig.)

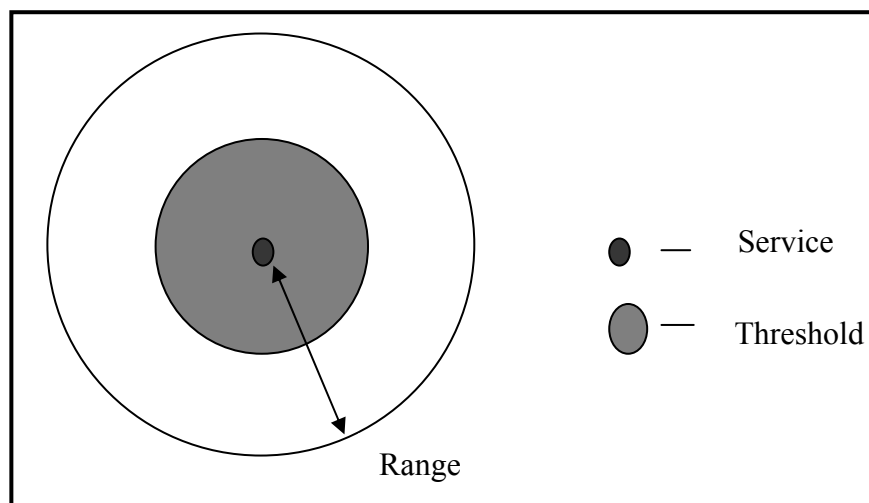


Figure 5: Illustration of Threshold and Range

4.3.4. Arrangement of the Central Places

As transport is equally easy in all direction, each central place will have a circular market area as shown in C in the following diagram: However, circular shape of the market areas results in either unserved areas or over-served areas. To solve this problem, Christaller suggested the hexagonal shape of the markets as shown in D in the above diagram. Within a given area there will be fewer high order cities and towns in relation to the lower order villages and hamlets. For any given order, theoretically the settlements will be equidistance from each other. The higher order settlements will be further apart than the lower order ones.

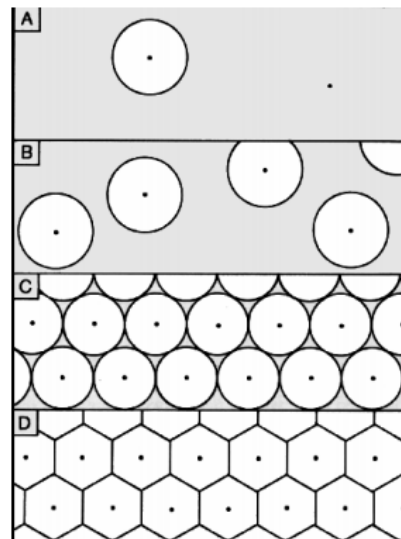


Figure 6: Development of Hexagonal Influence Area of Central Places in Several Phases

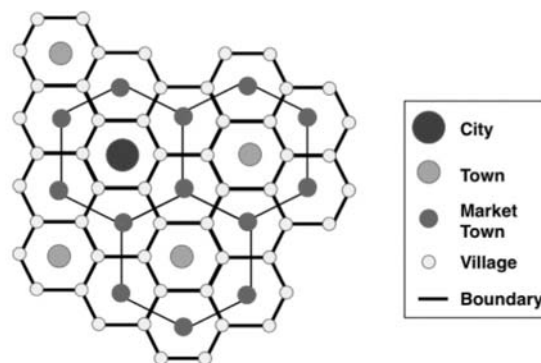


Figure 7: Hexagonal Areas of Influence
Source: Accessed from www.aboutcivil.org

4.3.5. The Three Principles of Central Place Theory

Christaller developed three principles to explain the arrangement of settlements. These are

1. The marketing principle ($K=3$ system);
2. The transportation principle ($K=4$ system);

3. The administrative principle (K=7 system).

In the marketing principle, one high order central place serves three (including itself) of the next lower order central places. When Central places are arranged according to the traffic principle, the lower order centres are located at the midpoint of each side of the hexagon rather than at the corner. Thus the transport principle produces a hierarchy organized in a $k=4$ arrangement in which central places are nested according to the rule of four. In the administrative principle, all the six next order settlements are fully covered by the central place and thus making the value seven.

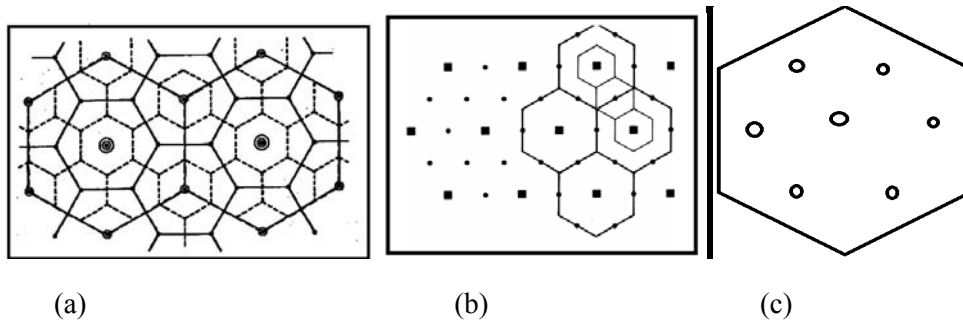


Figure 8: a) Market Principle ($K = 3$), b) Transport Principle ($K=4$), c) Administrative Principle ($K=7$)

The marketing principle

The above diagram (5a) shows the arrangement of the central places according to the marketing principle. There are _____ orders of central places. (note: There can be many orders of settlement.) (a) First order service centre providing first order services (b) Second order service centre providing second order services. (c) Third order service centre providing third order services. The different orders of settlements arrange themselves in a hierarchy. Generally speaking lower is the order, larger is the number of settlements and higher the order, greater is the area served.

If the arrangement of the settlements is according to the principle $k=3$, the theoretical number of settlements will progressively divide the previous order by 3 as shown in the following table:

Order	Cumulative total	Actual number
7th order	1	1
6th order	3	
5th order	9	
4th order		
3 rd Order		
2 nd Order		
1st order		

One high order central place is serving three (including itself) of the next lower order central places. The relationship of the market area between a lower order centre and the centres of the higher level can also be indicated by the value 3.

The Transportation Principle

Christaller pointed out that the marketing principle is an awkward arrangement in terms of connecting different levels of the hierarchy. As an alternate arrangement, Christaller suggested that central places could be organized according to what he called the transport principle.

The traffic principles states that the distribution of central places is most favourable when as many important places as possible lie on one traffic route between two important towns, the route being established as straight and as cheap as possible. The more unimportant places may be left aside. According to the transport principle, the central places would thus be lined up on straight traffic routes which fan out from the central point.

When Central places are arranged according to the traffic principle, the lower order centres are located at the midpoint of each side of the hexagon rather than at the corner. Thus the transport principle produces a hierarchy organized in a $k=4$ arrangement in which central places are nested according to the rule of four.

The Administrative Principle

Christaller's other suggested organizing principle was based upon the realization that from a political or administrative viewpoint centres it was unrealistic for centres to be 'shared'. Any pattern of control which cuts through functional units is potentially problematical. Christaller suggested that an arrangement whereby lower order centres were entirely within the hexagon of the higher order centre would obviate such problems. Such a pattern is shown in the following diagram. All the six lower order centres are fully subordinate to the higher order centre which, therefore, dominates the equivalent of seven market areas at the next lowest level.

4.3.6. Evaluation of the Central Place Theory

- Christaller has successfully explained that there is no rural-urban dichotomy and all settlements are a continuum.
- He has also explained that the higher order settlements are located wide apart and the lower order settlements are located close to each other.
- It holds merit in describing the hierarchy of the settlements.

However, this theory suffers from few limitations such as

- ❖ As it is based on several pre-conditions, this theory cannot be applied everywhere. If the homogenous flat region is interrupted by the presence of river, plateau or a hill, this model will not work.
- ❖ People do not always go to the nearest service centre. Sometimes it depends on their preferences also.

What are the advantages of central place theory?

The theory does a reasonably good job of describing the spatial pattern of urbanization. No other economic theory explains why there is a hierarchy of urban centres. Heilbrun wrote: 'A hierarchy is by definition a systematic arrangement of the classes of an object.' In this case, the object is economic centres, large and small. The central place hierarchy provides a description of the relationship between a central place--higher order place--and its tributary areas--lower order places. Once this hierarchy is pointed out, anyone can see it. (An aside: There is a hierarchy of towns in North Dakota--

and make no mistake about it, the four cities top that hierarchy. Hierarchy has become a dirty word in some academic circles, but with central place theory, hierarchy is as natural as the ecological spread of vegetation. The question is--will there be a stable long lasting relationship, or a 'dysfunctional' one? In biology, if one species dominates too much, it ends up killing itself off. The cities need the 'export dollars' provided by people in small towns, and the small towns need the specialized services provided by the cities. A strategy which helps both of them develop--in which state level development resources are shared--seems to be reasonable and wise.)

Central place theory does a good job of describing the location of trade and service activity. It also does a good job of describing consumer market oriented manufacturing. Trade and service activity has an increasing relevance as the U.S. economy shifts from manufacturing to services over time. Small-town community economic developers can secure quite specific, relevant information about what kind of trade or service enterprise will likely work, and what kind of enterprise will not likely work in a given small community

5.0 Types, Patterns and Segregation of Rural Settlements in India

5.1 Settlement Types

Settlements are an important aspect of Human Geography. They show the complex relationship of human occupancies of land and the environment. According to Enayat Ahmad (1965) 'type' mean the characteristics grouping of rural dwellings in that well defined parcel of ground which is known as 'Mauza', but this definition is useful only in local consideration. In a regional framework the term type indicates 'the relationship between settlements within the space' (Doxiadis, 1968). M. Aurrousseau (1920) expressed it as 'arrangement of rural I settlements as geographical entities to express the grouping of dwellings and their interrelationship'. In fact, types and patterns are two integral parts of rural settlement morphology. Settlement types refer to the spacing between two houses. There are three major types of rural settlements – compact or nucleated, uniform and dispersed. Nearest neighbour analysis is applied to determine the settlement types.

Factors Determining Settlement Types

There are two factors, physical and cultural, responsible for various settlement types in rural areas. They are also known as agglomerating factors or degglomerating factors. In physical factors relief, fertility of soil, amount of rainfall, dry land and defence are included, while in cultural factors land use, land tenure, cropping pattern, clan and caste system, social relationships and means of transportation are included.

The compact farm villages are common features of great fertile river valley plains. Similarly in flood affected area, few elevated sites are also having compact settlements. Settlements are generally found near water bodies. Availability of different sources of water gives rise to compact settlements. In low water table area where the construction of wells is costly, settlements around these wells are compact. However in the high water table area where wells can be dug easily, hamlets, semi-compact settlements are commonly found. On uniform relief, the settlements tended to concentrate in compact form, while in rugged land dispersed settlements are found. Also in the areas of harsh climate and infertile soil dispersed settlements are more common.

Cultural factors such as land tenure system of agriculture, peaceful conditions, and social customs in relation to untouchable give rise to dispersion. Rail road network attract the settlers to settle in dispersed manner. Similarly modern technology, developments in agricultural, political or

administrative decisions, religious or social conditions are also important in the study of settlement types.

The semi-compact settlement is an intermediate type between the zones of compact and sprinkled settlements and is more common in the extensive fertile areas where the water table is high and wells can be sunk, easily.

Dispersed or isolated settlement pattern in India appears in the form of isolated huts or hamlets of few huts in remote jungles, or on small hills with farms or pasture on the slopes. Extreme dispersion of settlement is often caused by extremely fragmented nature of the terrain and land resource base of habitable areas i.e. life is very harsh there. Many areas of Meghalaya, Uttaranchal, Himachal Pradesh and Kerala have this type of settlement.

Table 1: Comparison between Nucleated, Uniform and Dispersed Settlement Types

	Nucleated	Uniform	Dispersed
Characteristics	Houses are densely located.	Uniform distribution	Spread over a distant area
NNA Values	<1	1	>1 to 2.149
Examples	Mumbai, Kolkata	N. A.	Villages in Jodhpur

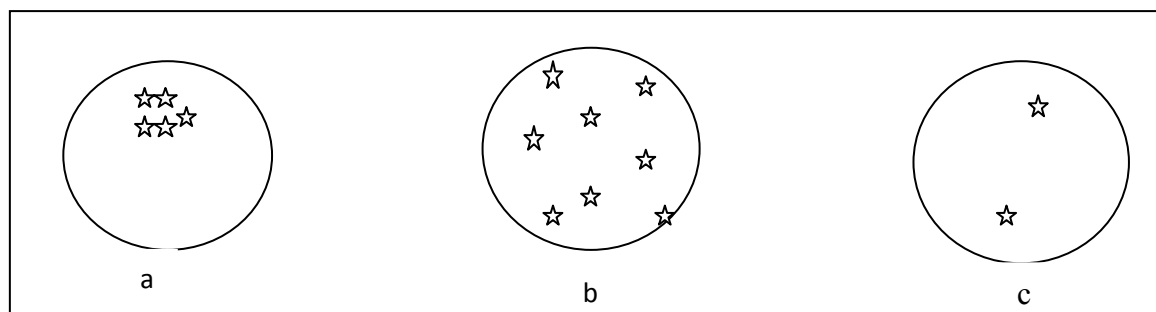


Figure 9: Settlement Types – (a) Nucleated, (b) Uniform and (c) Dispersed



Plate 1: Settlement Types – a) Compact, b) Semi-compact, c) Dispersed

5.2 Settlement Patterns

Settlement patterns are the expressions of space organization by a culture group and it presents the structure and resource perception of the inhabitants. The availability of resources, physical environment, the technological know-how of people and the culture of a group determine the settlement patterns. Availability of water, road transport networks, terrain etc. play important roles in determining the settlement patterns. The major types of rural settlements are – linear, rectangular, circular, hexagonal, star, T-shape, L-shape, J-shape etc.

▪ Rectangular Settlements

The rectangular shape is common in the areas where settlements are agglomerated and compact. Some settlements have rectangular arrangement both in the internal arrangement of lanes and houses and in the external outline. Some rectangular settlements have internal arrangements which are not perfectly rectangular but largely conform to it. The rectangular compact settlements patterns are found usually in plain uniform surfaces where agriculture is uniformly carried out. There is an obvious relationship between the field patterns and the shape of the village. This fact is true in the Ganga plains and its adjoining areas. In the whole of the northern plain areas the unit of measurement is '*bigha*' which is a square unit of land. The fields also have boundaries north-south and east-west to give a rectangular shape to the villages. The lanes connecting these fields also run in the same direction and hence form a rectangular pattern. The rectangular and square forms are easy to design and measure.

With the Aryans who developed sound knowledge of geometrical figures which are symmetrical, these two types seem to be the most favoured ones. The Aryan houses are also four cornered, four walled and rectangular in shape. The ancient villages depicted on sculptures, and described in Silpa Sutras also give details of village shapes. Manasaras also refer to the eight common plans of the villages all of which are rectangular (Havell, 1915). The religion played a very significant role in determining the orientation of the village. The Arthashastra is also full of numerous plans of Aryan villages and towns containing four principal gates dedicated to four principal gods (Havell, 1915). The eastern gate was dedicated to Brahma, southern to Indra, the western to Yama, the lord of Death, northern to Kartikeya etc. Thus the Aryan settlers were conscious of the orientation of their villages and houses. It is considered inauspicious and unreligious to lay one's head towards the north. In fact, every movement in our daily life is expressed and also understood with reference to the cardinal points of the compass. Therefore, throughout all the historical periods in India, the basic urges of man in matter of construction of houses, their position, lanes, doors, and facing had been according to the cardinal points of the compass.

Superstitions have also been playing their part for the rectangular shape of the houses. East-west elongation of a house is also avoided. The inner arrangement of lanes becomes rectangular, corresponding to the external rectangular form. In some villages however, the internal lanes are irregular even if the outer shape is regular and rectangular. In many well organized agricultural villages, the morphology is composed of number of rectangular blocks, separated by parallel lanes cutting each other at right angles. These patterns grid planned evolved in large villages to facilitate the movement of population and agricultural commodities to the market places. In some villages a grid plan with numerous lanes crossings are made to facilitate accessibility to various points of importance in the villages like the temple, well, tank, and the shops.

▪ Square Settlements

Next to the rectangular settlements are the square settlements. These are found in such areas where the settlement boundaries are limited by such restrictive features as waterlines, tanks, groves etc. The settlements do not become elongated. Some of these types of settlements are formed at the road crossing or at the intersection of roads, dividing the settlement morphology into four parts each one

appearing to be a separate block. Such type of settlements when grow in size take the shape of rectangular or a polygon.

- **Circular pattern**

Circular settlements develop around lakes, tanks and sometimes the village is planned in such a way that the central part remains open and is used for keeping the animals to protect them from wild animals. Such type is generally missing from the low-lying areas or plains which are the habitat of compact clusters. The loose clustering of individual dwellings in the hilly forested areas often acquires circular shape. The circular plan of the settlements is attributable to the shape of the site. The spurs are some of the most convenient points for such type of settlements. A large number of elongated clusters have oval shape. The oval-shaped clusters are frequently located on the elongated divides through which pass cart-tracks and country roads. They become elongated along the longer axis of the cart-tracks.

- **Star like pattern**

Where several roads converge, star shaped settlements develop by the houses built along the roads.

- **T-shaped**

T-shaped settlements develop at tri-junctions of the roads. Triangular, villages have three bounding lanes one of them runs perpendicular from the apex to the base. Some of triangular villages are sited on the triangular inter-fluvial plains. The bases of such triangular settlements lie upstream while the apex points towards the confluence. The internal arrangement of lanes is rectangular and external outline sometimes resembles fan shaped settlements. In the case of fan plan village the focal points are the road turning, road terminus, a river bend or a tank. Some of the rural settlements originally having 'T' shape overgrowth to a triangular shape, particularly when both the sides of T-villages have equally significant linear features.

- **Cruciform settlements** develop on the cross-roads and houses extend in all the four direction.

- **Ring and U-shaped Settlements**

In the areas having circular on U-shaped water bodies, such as an ox-bow lake, an interesting ring or U-shaped morphology develops. The perfection depends upon the area and such type of villages may be compact or loose clusters.

- **Polygonal Settlements**

The outer forms of some Indian villages are pentagonal or hexagonal. These forms are in .between the circular or rectangular. The population of rectangular or circular village when multiplied gradually, distortion of shape takes place due to physical constraints of the area. The outer forms of the settlement conform to the location, size and shape of such natural features as rivers, mounds, groves, hillocks, ponds etc. The restricted growth of this type takes the form of polygonal morphological outline.

- **Hollow Centred Settlements**

The hollow represents partially or wholly un-built space in the heart of the village. This open space may be of any shape. In some villages it may be a meeting place, a temple, a mosque, a tank, a park or a public well. It may be a market or a ground for village fairs. In tribal village it may be a site for 'akhara'. In all cases, the open space serves as a central place for the village community and is the place of convergence in the village morphology. The principal lanes of the village cross at this point. In many villages, the village council meets to deliver justice and all concerned take oath by Brahma. The villages of this type are mentioned in the Vedic literature also.

▪ Irregular Morphological Patterns

These are the haphazard and unplanned growth of n settlements which do not fall in the well-defined categories. Their shapes do not fall in any recognizable shape. The inner pattern is complex, clumsy and irregular. Lanes are crooked, sinuous, and blind. They do not bear any relationship with other features. These are mostly of old villages.

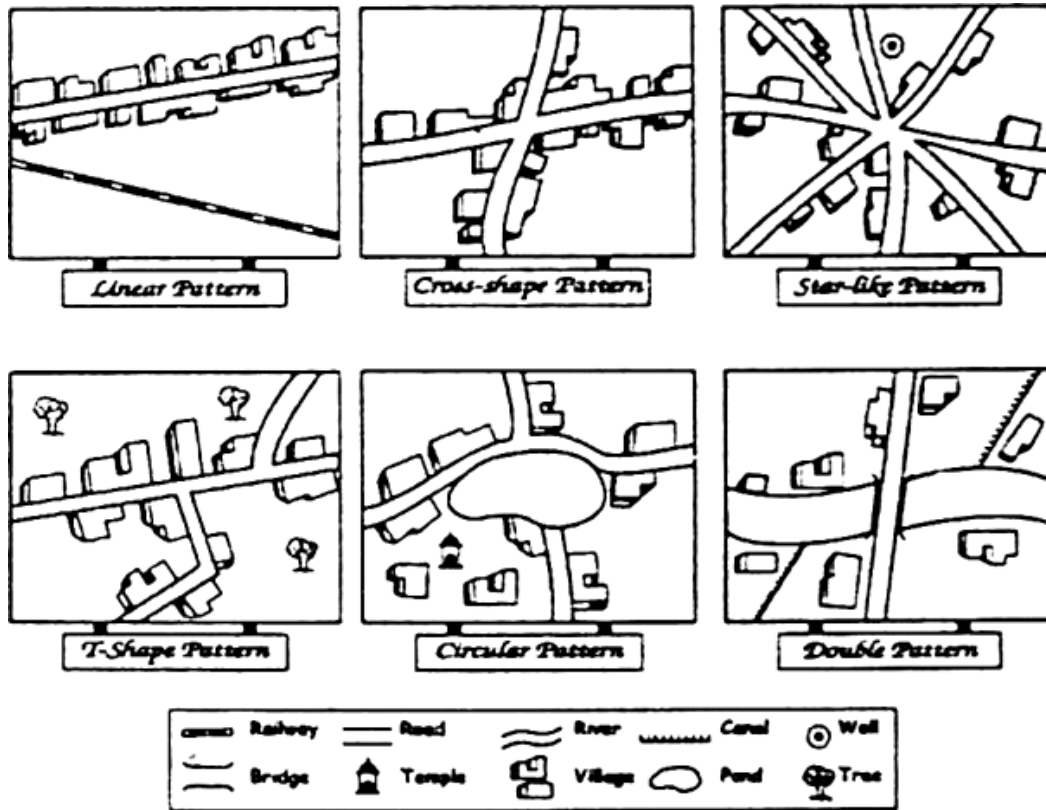


Figure 10: Settlement Patterns
Source: Accessed from www.zigya.com



From Left to Right:

Plate 2: Linear Settlement Plate

3: Rectangular settlements

Plate 4: Circular Settlement

Source: Accessed from www.alamy.com

6.0 Urban Definition – in India and in the Other Countries of the World

Table 2: Definition of Urban in India and in the World

Country	Definition of Urban
India	Any settlement having a minimum population of 5000, a threshold population density of 400 per sq. km, 75 per cent of male population working in non-farm sector, and the settlement having a statutory governing body in the form of municipality, municipal corporation, <i>nagar panchayat</i> or cantonment board is known as urban.
USA	Core census block groups or blocks that have a population density of at least 1,000 people per square mile (386 per square kilometer) and surrounding census blocks that have an overall density of at least 500 people per square mile (193 per square kilometer)
Canada	An area with a population of at least 1,000 people where the density is no fewer than 400 persons per square kilometre (1,000/sq mi)
Japan	contiguous areas of densely inhabited districts (DIDs) using census enumeration districts as units with a density requirement of 4,000 inhabitants per square kilometer
Australia	Population clusters of 1,000 or more people, with a density of at least 200/km
New Zealand	Areas having at least 1000 population and independent of any administrative subdivisions and have no legal basis
European countries	Urbanized areas are defined on the basis of urban-type land use, not allowing any gaps of typically more than 200 meters (220 yd), and use satellite imagery instead of census blocks to determine the boundaries of the urban area.

Criteria of an Indian Urban Area

There are three criteria to define an urban area:

- (i) Statutory criteria: Any area having a stationary/civic body like Municipality, Municipal Corporation Board, Nagar Panchayat, Notified Area Committee, or any type of local self-government.

- (ii) Demographic criteria: a minimum population of 5,000;– at least 75 % of male working population engaged in non-agricultural pursuits;– a density of population of at least 400 persons/sq. km
- (iii) Discretionary criteria: Respective state government and census authority may declare any area as urban e.g. pilgrim places, port area, coal mine area, project towns, campus area etc. The statutory criteria is considered first, while defining any settlement as town, the demographic criteria are used by census for settlements which does not comes in the category of town by statutory criteria. The town defined by demographic criteria by census is known as non-municipal or census towns.

Few Important urban centers of the world



a) New Delhi, India



c) Tokyo, Japan



b) Los Angeles, USA



d) Amsterdam, Netherlands

Plate 5: Few Important Urban Centers of the World
Source: Accessed from <https://en.wikipedia.org/>

7.0 Urbanization in India as Multi-Dimensional Process

7.2.1. History of Indian Urbanization

Among the developing countries, India holds the most significant position in urbanization. Although Indian urbanization is called a colonial legacy, urbanization in India started almost two thousand years before Christ. The history of Indian urbanization can be divided into five periods:

- i) The pre-historic period (2350-1800 BC)
- ii) The early-historic period (600 BC to 500 AD)
- iii) The medieval period (600 AD to 1800 AD)
- iv) The British period (1800 to 1947)
- v) The post-Independence Period (after 1947)

Urbanisation is an index of transformation from traditional rural economies to modern industrial one. It is progressive concentration (Davis, 1965) of population in urban unit. Quantification of urbanization is very difficult. It is a long term process. Kingsley Davis has explained urbanization as process (Davis, 1962) of switch from spread out pattern of human settlements to one of concentration in urban centres. It is a finite process--- a cycle through which a nation pass as they evolve from agrarian to industrial society. He has mentioned three stages in the process of urbanization.

Stage one is the initial stage characterized by rural traditional society with predominance in agriculture and dispersed pattern of settlements. Stage two refers to acceleration stage where basic restructuring of the economy and investments in social overhead capitals including transportation, communication take place. Proportion of urban population gradually increases from 25% to 40%, 50%, 60% and so on. Dependence on primary sector gradually dwindles. Third stage is known as terminal stage where urban population exceeds 70% or more. At this stage level of urbanization remains more or less same or constant. Rate of growth of urban population and total population becomes same at this terminal stage. The onset of modern and universal process of urbanization is relatively a recent phenomenon and is closely related with industrial revolution and associated economic development. As industrial revolution started in Western Europe, United Kingdom was the initiator of Industrial Revolution. Historical evidence suggests that urbanization process is inevitable and universal. Currently developed countries are characterized by high level of urbanization and some of them are in final stage of urbanization process and experiencing slowing down of urbanization due to host of factors). A majority of the developing countries, on the other hand started experiencing urbanization only since the middle of 20th century.

7.2.2 Causes of urbanization in India

The most important reason of urbanization is the migration from rural to urban areas. However, the reasons for this migration to urban areas in India may be summed up as follows:

- Trade based economy in colonial period,
- Industrial expansion in post-colonial period,
- Expansion in government services, as a result of the Second World War
- Migration of people, especially after the partition of India
- Eleventh five-year plan that aimed at urbanization for the economic development of India,
- Privatization of economy since 1990s

7.2.3 Volume and Trends of Indian Urbanization

India shares most characteristic features of urbanisation in the developing countries. Number of urban agglomeration /town has grown from 1827 in 1901 to 5161 in 2001. Number of total population has increased from 23.84 crores in 1901 to 102.7 crores in 2001 whereas number. Population residing in urban areas has increased from 2.58 crores in 1901 to 28.53 crore in 2001. It reflects a gradual increasing trend of urbanization. India is at acceleration stage of the process of urbanization.

Urbanization is the process of increase in proportion of urban population to the total population in an area over a certain time period. The main factor contributing to urbanization is the rural-urban migration. The degree of urbanization is calculated using the following formulae.

$$(X - Y) / Y$$

Where, X = Population of Present Year

Y = Population of Previous Year

Table 3: Indian Urbanization – At a Glance

Year	Agglomerations / Towns	Degree of Urbanization	Annual exponential Growth rate of Urban Population
1901	1827	10.84	
1911	1825	10.29	0.03
1921	1949	11.18	0.79
1931	2072	11.99	1.75
1941	2250	13.86	2.77
1951	2843	17.29	3.47
1961	2363	17.97	2.34
1971	2590	19.91	3.21
1981	3378	23.33	3.83
1991	3768	25.72	3.09
2001	5161	27.78	2.74
2011	7935	31.16	2.76

Source: http://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S000017GE/P001790/M025482/ET/1512715399PROCESSOFURBANIZATIONININDIA.pdf Accessed from

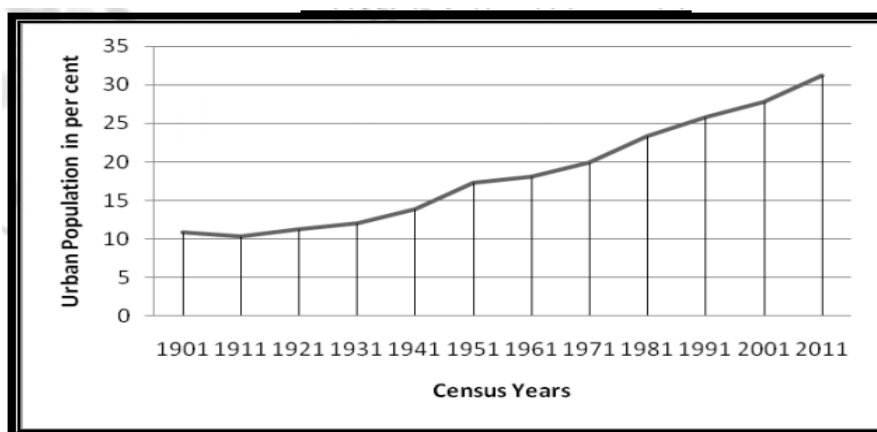


Figure 11: Indian Urbanization, 1901 to 2011

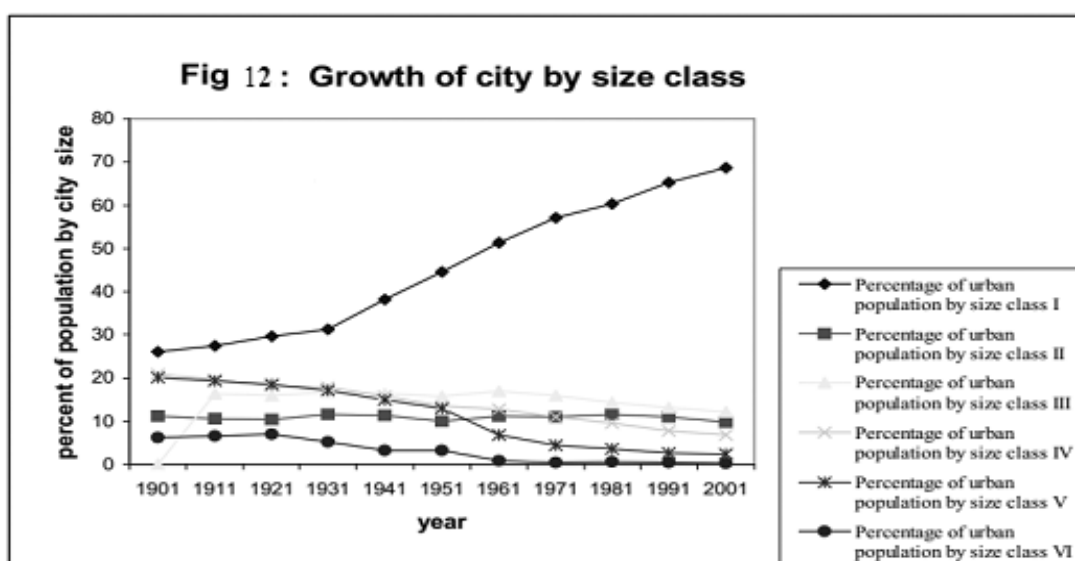
Source: Accessed from

http://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S000017GE/P001790/M025482/ET/1512715399PROCESSOFURBANIZATIONININDIA.pdf

7.2.4 Urban Morphology

The shows number of towns and percentage of urban population by size class of city during 1901- 2001. The pattern of urbanization in India is characterized by continuous concentration of population and activities in large cities. This is manifested in a high percentage of urban population being concentrated in class I cities and its population has systematically gone up over the decades in the last century. As per 1901 census percentage of population in class I, IV, V were 26%, 21%, and 20 per cent respectively. According to 1991 Census, about two third (65%) of the countries urban population lived in Class -I cities with more than 100, 000 population. In 2001 it has increased to 69%. Over the years there has been continuous concentration of population in class I towns.

On the contrary the concentration of population in medium and small town either fluctuated or declined. Indeed basic reason for the increasing dominance of class I cities is graduation of lower order towns into class I categories. It may be observed that in 1901 there were only 24 class-I cities that has gone up to 393 in 2001 which explains largely the increase in the share of population in this size category over the years. The graduation of number of urban centres from lower population size categories to class I cities has resulted top heavy structure of urban population in India. However in addition to factor of increase in number of large cities, the importance of a faster demographic growth, poverty induced migration to urban informal sector should be taken into account in making urban structure top heavy.



Source: Datta, 2006: 10

7.2.5 Components of Urban Growth

Urban growth can be attributed to mainly three components 1) Natural increase, 2) Net migration, 3) Areal reclassification. These components have been estimated using residual method. Since separate information in wake of change in the area and population due to extension of municipal boundaries during the inter-censal period is not available either for total or for migrant population it is difficult to estimate decadal migration to urban areas. Besides migration data for new and declassified towns are not available separately and so there is a possibility error in estimating contribution of migration in the share of urban growth. From table 9 it is evident that during 1971-81 about 41% of urban growth (estimated by Jain, RG 1991 Census) can be attributed to natural increase which reflects the role of demographic momentum, 36% due to net migration and municipal boundary changes and 19% due to reclassification of area.

But urban growth due to natural increase has increased from 42% in 1971-81 to about 60% during 1981-91. Urban growth due to migration and changes in municipal boundaries has reduced from 39% in 1971-81 to 22% in 1981-91. It is clear that urbanization process in India is not mainly "migration lead" but a product of demographic explosion due to natural increase. People migrate to cities not due to urban pull but due to rural push. Poverty led migration has induced very poor quality of urbanization followed by misery, poverty, unemployment, exploitation, rapid growth of slum, inequalities, degradation in the quality of urban life.

Table 4: Cities Developed in Different Periods

Time Periods	Different Cities
The Medieval Period	Agra, Surat, Hyderabad etc.
Colonial Period	Kolkata, Mumbai, Shimla, Panchmarhi etc.
Post-Independence Period	Kalyani, Durgapur, Haldia etc.

7.2.6 Trends and Patterns of Urbanisation: An Interstate Analysis

The variation in the urban share of total population across Indian states is high. The pattern, however, has undergone significant changes over the past few decades. A large proportion of urban population is currently concentrated in the six most developed states, namely Maharashtra, Gujarat, Tamil Nadu, Karnataka, Punjab and West Bengal, accounting for about half of the country's urban population. This pattern is an inheritance from the colonial period and all these states report a percentage of urban population much higher than the national average of 27.8 in 2001. Several studies have shown that the levels of urbanisation in the states with high per capita income are generally high, the opposite being the case in less urbanised states.

The pattern of urban growth across states is significantly different from that of the levels of urbanisation. From Independence until 1991, most of the developed states have shown medium or low growth of urban population. In contrast, high urban growth was registered in economically backward states, such as Assam, Bihar, Uttar Pradesh, Rajasthan, Himachal Pradesh and Madhya Pradesh, these states also having low percentages of urban population. The small north-eastern states deserve special mention as they too have recorded high urban growth through becoming economically integrated into the national economy. This, unfortunately, was not reflected in their levels of economic development. Overall, the relationship between level of urbanisation and urban growth works out to be negative. However, a couple of developed states like Maharashtra and Haryana may be considered as exceptions, as they have recorded urban growth slightly higher than that of the country. In short, the urban scenario in the post-Independence period was characterised by dualism.

The developed states attracted population in urban areas due to industrialisation and infrastructural investment but this was largely in and around large cities and upcoming industrial centres. Interestingly, the backward states too – particularly their backward districts and small and medium towns – experienced more rapid urban growth. This can be partly attributed to government investment in the district and taluka headquarters, programmes of urban industrial dispersal, and transfer of funds from the states to urban local bodies through a needs-based or what is popularly known as ‘gap-filling’ approach. A large part of rural–urban migration into smaller towns from their rural hinterland in backward states can, however, be explained in terms of push factors, owing to the lack of diversification in the agrarian economy. The rate of urban growth has gone down significantly between 1991 and 2001, as mentioned in the preceding section. More important than the decline in the growth of urban population, however, is the change in the pattern of urban growth in the 1990s, which makes a significant departure from earlier decades. During the four census decades after Independence until 1991, urban growth was generally high in relatively backward states, as noted above. A few of the developed states also attracted reasonable numbers of migrants to their urban centres but the overall relationship between urban growth and economic development across states works out to be slightly negative.

The 1990s, however, make a significant departure from this. Most of the developed states like Tamil Nadu, Punjab, Haryana, Maharashtra and Gujarat have registered urban growth above the national average. Karnataka has remained slightly below the national average and West Bengal is an exception whose growth rate is low due to the rural-oriented strategy followed by the state government. The backward states, on the other hand, have experienced growth either below the national average or, at most, equal to that. Making a comparison over the past two decades, the growth rates for developed states have either gone up or remained the same as in the 1980s. The backward states, however, have recorded either a decline or stability in their urban growth.

The urbanisation process has, thus, become concentrated in developed regions and larger cities in recent years, with backward areas and smaller towns tending to stagnate. This could, at least partly, be attributed to the measures of decentralisation rooted in the neoliberal policy paradigm

whereby the responsibilities of resource mobilisation and launching infrastructural projects have been given to state agencies, para-statal bodies and local governments, as discussed below. Large municipal bodies, particularly those located in developed states, tend to have a strong economic base, an advantage which clearly manifest in their high economic and demographic growth. The smaller towns in the backward states, on the other hand, have languished economically and reported low or negative demographic growth, many of them even failing to meet the criteria for classification as urban centres.

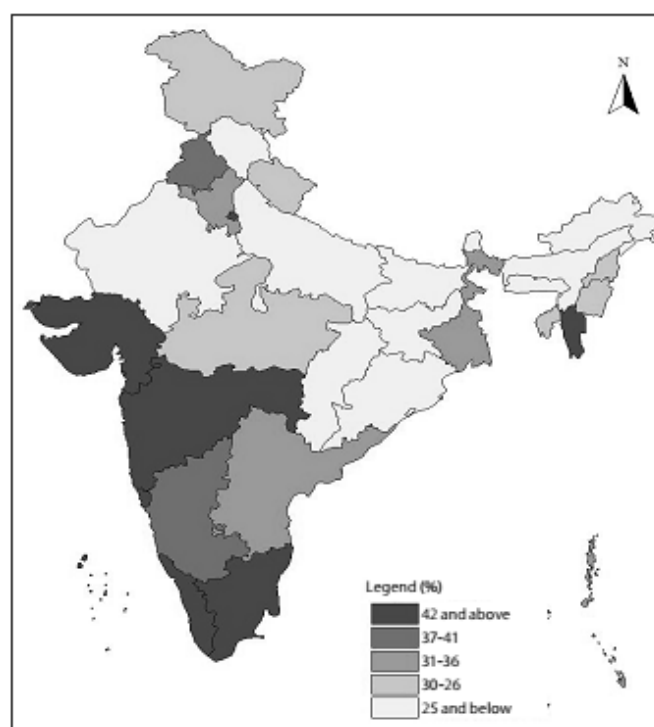


Figure 13: Levels of Urbanization in India in 2011
Source: Bhagat, 2011: 11

7.2.7 Emergence of Large Cities

The 2011 Census identifies 497 class I towns, i.e., those that are more than 1,00,000 in population (including stand-alone class I towns that are not part of any UA). What is the origin of these towns? What were these towns like in 1961, the first year when the current definition of urbanisation was used? Table 2a gives the transition matrix in terms of number of towns, while Table 2b provides it in terms of share of population. Of the 497 towns, 37 did not have any reported population in 1961. Of the 232 that had a population of less than 50,000 in 1961, two are today towns of more than one million. Table 2b shows that while 57% of the population of current million-plus towns lived in towns of 5,00,000 or more in 1961, 9% of the population were in towns of less than 1,00,000 or no reported population (Denis et al, 2012).

7.2.8 Census Towns

The Census of 2011 shows a large growth in census towns, i.e., urbanisation outside recognized urban local bodies. Pradhan (2012) has studied the spatial pattern of these settlements using an unexploited

source prepared by the Census of India, which lists all geographical units in 2011 and its mapping with the 2001 Census.¹⁰ Using the population of these settlements from the 2001 Census, it is possible to estimate their contribution to the increase in urbanisation and using their geocodes, study whether they are located in proximity to existing towns. Pradhan finds that 26% to 29.5% of the urban growth from 2001 to 2011 can be attributed to the recognition of new census towns, varying from a high of nearly 90% in Kerala and 60% in West Bengal to less than 10% in states like Karnataka and Gujarat.

By contrast, only 8.4% of the growth in urban population over 1991 to 2001 was due to new census towns. Not all of this growth of census towns is occurring around existing large towns. Using a differentiated spatial buffer around towns above 1,00,000,¹² he finds that only 37.2%, or 926 (of 2,489) of settlements and 33.6% of the population fall within these buffers, indicating that much of this growth is outside the peripheries of existing large towns. The spatial distribution of new census towns shows that while there is a high concentration in certain districts close to metropolitan cities, the formation of census towns is also widely spread across the country. This indicates that the process of spontaneous transformation of settlements reflected in the growth of census towns beyond metros, is a relatively widespread geographical phenomenon.

8.1 Million Cities

Cities which have a population of one million (10 Lakh) or above each are known as Million plus cities. According to the 2011 census, there were 27 million-plus cities in India, with Mumbai, Delhi and Kolkata having populations over 10 million.

The term 'million cities' was coined in the Indian context by Misra (1975) to indicate those large urban centres having a resident population of one million people or more. In his recent work, however, Misra (1998) has used the term metropolitan agglomerations. Bose (1993) had used the term M+ cities in his critique of urbanization in India but, afterwards, several hierarchies within the million plus city were recognized on the basis of population size. We would use the term million city in this analysis. At the beginning of this century, there was only one million city - Calcutta with a population of 1,488,323. This oldest metropolis of India has recently celebrated its 300th birth anniversary in 1990. Greater Bombay (now known as Briham Mumbai), itself not older than Calcutta, joined the list of million cities in 1911. Since the Independence in 1947, the numbers of million cities have grown at a tremendous pace but during the last two decades they have multiplied manifolds (Lahiri-Dutt, 2001).



Source: Census of India, 2001

8.2 Mega cities

A megacity is a very large city, typically with a metropolitan population in excess of 10 million people. A megacity can be a single metropolitan area or two or more metropolitan areas that converge. In India there are 4 megacities- Delhi, Mumbai, Kolkata and Bengaluru.

In India about 377 million that is 31.16 % of the total population of the country are living in the urban area according to 2011 Census compared to 28.6 % in 2001 Census. The number of metropolitan cities and its contribution to the total urban population are also on the rapid increase. In 1991, census the total number of million plus cities was 26 which increased to 35 in 2001. Now as per 2011 Census, there are 53 million plus cities. Also, the eight metropolitan cities have crossed the mark of five million to qualify as mega cities. Out of four mega cities, Calcutta is the only one which is situated in the eastern part of India, left behind in the pace development. Kolkata is the oldest among all metropolitan/mega cities which achieved the mark of one million in 1901. The Kolkata urban agglomeration is spread over an area of 1,033 sq. km. The urban agglomeration is formally administered by several local governments including 3 municipal corporations, 37 local municipalities, and one cantonment Board area. The Kolkata UA also consists of 75 census towns and 6 outgrowths according to Census 2011. Altogether there are a total 122 cities and towns in Kolkata UA. Kolkata lagged behind in the story of development after the Independence, but still not lost its importance as culturally, economically and strategically this is the nucleus of eastern and north-east India. The unique feature of Kolkata's regional location is that; there is no other major urban centre within a 100 km from Kolkata in the eastern India unlike other regions of the country. Thus, growth of Kolkata UA assumes special significance for the development of eastern and north-east India.



Figure 15: Indian Mega Cities

Typical Challenges that Mega Cities Face

- Slum
- Crime
- Homeless population
- Drug addiction
- Traffic congestion
- Air-pollution
- Urban sprawl

8.3 Megalopolis

A megalopolis is typically defined as a chain of roughly adjacent metropolitan areas. The term was used by Patrick Geddes in his 1915 book *Cities in Evolution*. A megalopolis, also known as a mega-region, is a clustered network of cities. Gottmann defined its population as 25 million. It is the bloated city, where material wealth dominates life. This stage marks the beginning of the decline, e.g., Rome in the second stage.

There is little doubt that the metropolitan area is becoming the dominant form of settlement all over the world. There is a growing concentration in the largest 'Primate' cities. The questions that arise are; how did the concept of 'Metropolitan area' evolve? How did the traditional distinction between "City" and "Suburb" become obsolete and meaningless? Both the city and suburbs have merged into a new and much more extended form of human settlement. In its 1950 census, the United States recognized this fact under the name of the "Metropolitan area." As accepted by the researchers that there is no limit to the size and growth of the urban area, further growth of the "metropolitan area" has created a gigantic agglomeration all over the world. It is seen that the large share of the urban population has concentrated in a few gigantic urban metropolis which is called the "Megalopolis." The term Megalopolis became popular when it was used by Jean Gottmann in 1960s, in his study, "The urbanized North-eastern seaboard of the United States", being 500 miles long and 30 to 100 miles wide (measuring total geographical area about 53,575 sq. Miles). A highly urbanized area in 1960 was called "Megalopolis" by Jean Gottmann.

The word 'Megalopolis' has been used in different sense by various people. The WEBSTER dictionary defines it as, 'a very large city' and therefore sometimes it is just used in its literal meaning of "big city". Others use it to denote a cluster or string of metropolitan areas. The late Konstantinos Doxiadis and his followers believed that these constitute a new type of human settlement, which is

different from the metropolis. In nutshell Megalopolis is nothing but, “a Concentration of urban population in large magnitude, covering a large area with series of urban settlements having interaction with each other and yet each of them maintaining its own identity”. Such a highly urbanized area can be termed as “Megalopolis”. However, the Megalopolis is something different from conurbation as seen in case of Calcutta and Bombay. In the Megalopolis there are series of urban settlements of different levels having good functional linkages (backward and forward) and each settlement has its own economic base and identity. Structurally the hinterland of each urban centre gets merged with each other in such a way that the entire area becomes an urban field having many urban centres located in a continuous zone over space.

8.4 Ecumenopolis

Ecumenopolis is the hypothetical concept of a planet-wide city. The word was invented in 1967 by the Greek city planner Constantinos Doxiadis to represent the idea that in the future urban areas and megalopolises would eventually fuse and there would be a single continuous worldwide city as a progression from the current urbanization, population growth, transport and human networks. According to Doxiadis (1968: 15-16),

Such cities, growing dynamically over the next two or three generations, will finally be interconnected, in one continuous network, into one universal city which we call the ecumenic city, the city of the whole inhabited earth, or Ecumenopolis. If we speak, therefore, of the cities of the future one century from now, we can state that they will have become one city, the unique city of mankind.

This evolution corresponds to an age-old dream of man who, very early, started thinking of cosmopolis -- not as a physical entity, but as the ideal state in which all people will be equal and united into one world. In the Greek tradition, cosmopolis, unlike paradise, was on the surface of the earth, and unlike Utopias it had a specific place and in some vague way was supposed to be a good place for man, an eutopia. The idea of cosmopolis has been important throughout human history. In the West it began, in the first half of the 4th century B.C., with the Cynics in Greece, who did not believe in the world-city (as their word cosmopolis has gradually come to imply) but, on the contrary, believed that man should have no city of his own -- the whole cosmos should be his dwelling place.

At the same time, other Greek philosophers were trying to find a meaning in the whole cosmos. The Stoics in the 3rd century B.C. connected the concept of a world state with the external universe of man. Similar ideas were developed during the period of the Roman Empire, although nobody regarded the empire itself as cosmopolis. In China, where philosophers dreamed of a universal state, a great empire was created in the 3rd century B.C.; another appeared in India at the time of the great Buddhist Emperor Asoka (3rd century B.C.) when, according to W. Wagar, “Utopia and Cosmopolis merge in a single splendid image.” In the Christian West the idea of a universal state was as appealing as the idea of paradise: during the period of the Roman and Byzantine empires it coincided with political goals; during feudal times it was related to the notion of one church. Similarly, the Arabs were moved to create their empires by the dream of an Islamic world.

In the modern world, several proposals for a unified Europe appeared in the 17th century, and the 19th century produced “more prophets of world integration than 16 any other in history, but more than ever they were voices in the wilderness, scattered and impotent.” This was true in many countries, especially in Europe and Russia, and it is useful to remember that the greatest number of Utopias was produced in the same century. In the 20th century, which begins with H. G. Wells and his “world brain,” Arnold Toynbee, Lewis Mumford, Aldous Huxley, and Erich Kahler, among others, have defended the necessity of a world order and a world state, that is, of a cosmopolis. Teilhard de Chardin speaks of the noo-sphere or sphere of ideas -- in a different sense, the brain of cosmopolis.

By now we can see that the idea of cosmopolis tends to take on a physical expression as the Ecumenopolis of the 21st century. This city already exists in terms of the transmission of news, which

has reduced the earth to the dimensions of a city; it is gradually coming to be expressed in terms of air transportation, as the major airports become the busy squares of Ecumenopolis; and it tends to be expressed in many other ways.

There is no doubt about it, this city of the future is already under construction. The big question that arises is not about its dimensions, structure, and form, but about the function of Ecumenopolis, the type of life that will be created within it, and the quality that Ecumenopolis will offer to man. This cannot be foreseen, because we do not know what kind of imagination and courage modern man will have to develop in order to create a high quality of life within an Ecumenopolis of such dimensions.

What we can foresee is that if the existing forces continue to develop as they do at present and if man reacts as he has so far, Ecumenopolis with its extra-human dimensions will turn into an inhuman city where all the weaknesses of today's cities will be multiplied manifold. Under such conditions, Ecumenopolis will choke itself -- and man as a civilized being -- to death. Ecumenopolis will then turn into the city of death or, as Lewis Mumford called the city in such situations, into the Necropolis.

It now becomes clear that man is facing two alternate roads: either to allow the extra-human Ecumenopolis to become inhuman, leading to its virtual death; or to turn it, in spite of its extra-human dimensions, into a very human city. This is his great challenge and he can meet it if he takes it seriously.

9.1 Urban Sprawl

The urban areas gradually increase in size and these encroach the adjacent rural areas, the agricultural fields. This process of urbanization is known as urban sprawl. According to Whyte (1958), urban sprawl is the growth of cities through the process of scattered development of miscellaneous types of land use in isolated locations on the fringe, followed by the transformation of the spaces with similar uses. While Bosselman (1968) has stated the adverse effects of urban sprawl on the fringes, having an inefficient and unpleasant environment on the urban fringe. Gradually, the adjacent villages come under the urban areas. This is caused by the migration of interior villagers on the less costly fringe areas of the cities. Sometimes urban planners take the policy of urban sprawl to diffuse the highly dense cities by offering low cost residential areas in the fringes of the cities.

The term "urban sprawl" was first used in an article in The Times in 1955 as a negative comment on the state of London's outskirts.

Identification of the causes of urban sprawl

Conditions favorable to urban sprawl can be identified as follows:

- lower land price compared to developed areas of the main city
- availability of un-built agricultural land
- high rate of urbanization and rapid development activities
- availability of some municipal services in mixed development without paying for it
- less control on urban development being located outside the urban limit
- lower taxes on industries
- influence of speculators on the agricultural land owners for selling land to developers

- high rate of urbanization
- results of failure to match demand of urban infrastructure and services

Presently, Indian cities are home to an estimated 377 million people or 31.16% of the country's total population. While traditionally this urbanisation was oriented towards the large cities, the growth rates in these cities have declined since 1991 and faster growth is now observed in the adjoining districts.

For example, Greater Mumbai, India's largest metropolis by population, witnessed an annual growth rate of 0.4%, while Thane, which borders Greater Mumbai to the north grew at 3.1% annually. Similarly, Delhi district witnessed a growth rate of 1.9% annually, while Gurgaon district just to the south, grew at an annual rate of 4.5%. By 2031, while there is an anticipated growth in diverse and widespread large and small urban centres, the 11 megacities in India will continue to dominate the India urban landscape in sheer population numbers.

There is a significant growth in the number of classified towns and urban agglomerations across India. The largest increase is seen in census towns - areas having urban features, but lacking any institutional setup such as a municipal body or cantonment board for governance.

Much of this growth has occurred in sprawl like manner with low density and large spatial footprints. In accordance with the Agglomeration Index, the World Bank in their report, 'Leveraging Urbanisation in South Asia: Managing Spatial Transformation for Prosperity and Livability', has estimated that urban sprawl actually accounts for 55.3% of India's total population, indicating a wide gap between the official census figure of 31%. The report estimates that urban footprints are growing at twice the rate of urban populations, reflected directly in the increasing urban sprawls.

Effects of Urban Sprawl

Urban sprawl has resulted in loss of productive agricultural lands, open green spaces and loss of surface water bodies. It also increases the land-values and thus making these costlier for low-earning people. Uninterrupted growth leads to unplanned settlement growth and thus impairing the ecological balance.



Plate 6: Urban sprawl

Source: Accessed from makanaka.wordpress.com

9.2 Urban Renewal

Urban Renewal in India is a comprehensive presentation of the theoretical, strategic and technical aspects of urban renewal. The term ‘urban renewal’ implies redevelopment of urban areas to ensure growth of infrastructure, promotion of tourism and better quality of life. It has been identified across the world as one of the most crucial processes for ensuring optimal development of urban spaces.

To expedite investment and effective planning in urban infrastructure and service provision, the Government of India has been launching several schemes/programmes—for example, Environmental Improvement of Urban Slums (1972), Integrated Urban Development Programme (1974–1979), Integrated Development of Small and Medium Towns (1975), Mega City Scheme (1992–1997), Two Million Housing Programme (1998–1999), Valmiki Ambedkar Awas Yojana (2001), Total Sanitation Campaign (1992 renamed Nirmal Bharat Abhiyan in 2012), Urban Reform Incentive Fund (2003), and Pooled Finance Development Scheme (2006). However, the turning point of bringing the urban development agenda into focus was achieved with the launch of the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) in December 2005.

9.2.1 Jawaharlal Nehru National Urban Renewal Mission (JNNURM)

JNNURM is the first massive urban development programme of the country and has established the foundation for large-scale central assistance to the urban sector. It was launched as a reform-driven and fast-track programme to catalyse planned development of identified cities. The programme has been operating in mission mode by facilitating large-scale investments in the urban sector and policy and institutional reforms, leading to sustainable socio-economic growth in cities. The mission has sought to achieve this by integrating the development of infrastructure services and accelerating the flow of investment into urban infrastructure; through planned development, redevelopment and renewal of cities, inner-city areas, peri-urban areas, outgrowths, and urban corridors; and through universal service delivery for the urban poor. A number of urban projects were sanctioned under JNNURM during 2005–2014, and central assistance of approximately 48,000 crore INR was committed during this period through the mission.

JNNURM is a large umbrella mission with multiple sub-missions aimed at achieving varied outcomes without any specific priority ordering of objectives. The mission has sought to encourage reforms and planned development across various components, covering:

- Urban renewal, including renewal and redevelopment of inner city areas;
- Water supply and sanitation;
- Sewerage and solid waste management (SWM);
- Storm water drains;
- Urban transport (roads, flyovers, mass rapid transit system [MRTS], bus, etc.);
- Parking lots and spaces on a public-private partnership (PPP) basis;
- Development of heritage areas;
- Preservation of water bodies;
- Prevention and rehabilitation of soil erosion and landslides in case of special category states

During 2014–15, the central government launched four new schemes to expedite urban infrastructure and service provision and replace JNNURM. These schemes are (1) the Atal Mission for Rejuvenation and Urban Transformation (AMRUT), focussing on water supply and sewerage improvement; (2) Smart Cities Mission (SCM), aimed at developing smart solutions for selected urban areas; (3) Swachh Bharat Mission (SBM), focussed on waste management and sanitation; and (4) Heritage City Development and Augmentation Yojana (HRIDAY), for addressing the development of heritage cities. It will be interesting to study the differences and similarities between

JNNURM and new missions to understand how the approach to urban development has changed in India.

9.2.2 Atal Mission for Rejuvenation and Urban Transformation (AMRUT)

AMRUT is a focussed urban infrastructure development mission that seeks to encourage capacity building and reform implementation. Its main objective is to ensure universal access to water supply and sewerage. The mission also includes other components, such as improving storm water drains to reduce flooding; pedestrian, nonmotorised and public transport facilities; parking spaces; and green spaces, parks and recreation centres, especially for children.

9.2.3 Smart Cities Mission (SCM)

The first question is what is meant by a ‘smart city’. The answer is, there is no universally accepted definition of a smart city. It means different things to different people. The conceptualisation of Smart City, therefore, varies from city to city and country to country, depending on the level of development, willingness to change and reform, resources and aspirations of the city residents. A smart city would have a different connotation in India than, say, Europe. Even in India, there is no one way of defining a smart city. Some definitional boundaries are required to guide cities in the Mission. In the imagination of any city dweller in India, the picture of a smart city contains a wish list of infrastructure and services that describes his or her level of aspiration. To provide for the aspirations and needs of the citizens, urban planners ideally aim at developing the entire urban eco-system, which is represented by the four pillars of comprehensive development-institutional, physical, social and economic infrastructure. This can be a long term goal and cities can work towards developing such comprehensive infrastructure incrementally, adding on layers of ‘smartness’.

In the approach of the Smart Cities Mission, the objective is to promote cities that provide core infrastructure and give a decent quality of life to its citizens, a clean and sustainable environment and application of ‘Smart’ Solutions. The focus is on sustainable and inclusive development and the idea is to look at compact areas, create a replicable model which will act like a light house to other aspiring cities. The Smart Cities Mission of the Government is a bold, new initiative. It is meant to set examples that can be replicated both within and outside the Smart City, catalysing the creation of similar Smart Cities in various regions and parts of the country. The core infrastructure elements in a smart city would include:

- i. adequate water supply,
- ii. assured electricity supply,
- iii. sanitation, including solid waste management,
- iv. efficient urban mobility and public transport,
- v. affordable housing, especially for the poor,
- vi. robust IT connectivity and digitalization,
- vii. good governance, especially e-Governance and citizen participation,
- viii. sustainable environment,
- ix. safety and security of citizens, particularly women, children and the elderly, and
- x. health and education. As far as Smart Solutions are concerned, an illustrative list is given below.

This is not, however, an exhaustive list, and cities are free to add more applications.

Therefore, SCM is another focussed urban mission that seeks to identify and apply ‘smart solutions’ to develop select cities as model smart cities. Smart solutions will improve the provision of urban infrastructure and services; they cover water and sanitation, electricity, urban mobility and

public transport, affordable housing, IT connectivity and digitalisation, e-governance and citizen participation, sustainable environment, citizen safety, and health and education.

9.2.4 Swachh Bharat Mission (SBM)

SBM-urban1 seeks to address specific issues— namely open defecation, manual scavenging, SWM, and general awareness and behaviour towards healthy sanitation practices and their linkages to public health. Thus, the mission components include provision of household, community and public toilets; effective SWM techniques; public awareness campaigns; and capacity building of implementing bodies.

The objectives of the mission are mentioned below:

- Elimination of open defecation
- Eradication of Manual Scavenging
- Modern and Scientific Municipal Solid Waste Management
- To effect behavioral change regarding healthy sanitation practices
- Generate awareness about sanitation and its linkage with public health
- Capacity Augmentation for ULB's
- To create an enabling environment for private sector participation in Capex (capital expenditure) and Opex (operation and maintenance)

The Mission has the following components:

- i. Household toilets, including conversion of insanitary latrines into pour-flush latrines;
- ii. Community toilets
- iii. Public toilets
- iv. Solid waste management
- v. IEC & Public Awareness
- vi. Capacity building and Administrative & Office Expenses (A&OE)



Plate 7: Swachh Bharat Mission

9.2.5 Heritage City Development and Augmentation Yojana (HRIDAY)

The Ministry of Housing and Urban Affairs, Government of India, launched the National Heritage City Development and Augmentation Yojana (HRIDAY) scheme on 21st January, 2015, with a focus on holistic development of heritage cities. The scheme aims to preserve and revitalise

soul of the heritage city to reflect the city's unique character by encouraging aesthetically appealing, accessible, informative & secured environment.

With a duration of 4 years 3 months (up to March, 2019) and a total outlay of INR 500 Crores, the Scheme is being implemented in 12 identified Cities namely, Ajmer, Amaravati, Amritsar, Badami, Dwarka, Gaya, Kanchipuram, Mathura, Puri, Varanasi, Velankanni and Warangal. The scheme is implemented in a mission mode.

The Scheme supports development of core heritage infrastructure projects which shall include revitalization of urban infrastructure for areas around heritage assets identified / approved by the Ministry of Culture, Government of India and State Governments. These initiatives shall include development of water supply, sanitation, drainage, waste management, approach roads, footpaths, street lights, tourist conveniences, electricity wiring, landscaping and such citizen services.

HRIDAY seeks to undertake strategic and planned development to ensure sustainable growth of selected heritage cities. The objective is to improve the overall quality of life, with a specific focus on sanitation, security, tourism, heritage revitalisation and livelihood creation while retaining the cultural identity of a heritage city. Broadly, HRIDAY will focus on four theme areas—physical, institutional, economic and social infrastructure—to achieve the objective of revitalising heritage cities.

The first city of India to enter the list, Ahmedabad was declared as the World Heritage City on July 8, 2017. The city of Ahmedabad has close to 25 ASI (Archaeological Survey of India) protected structures. The walled city of Ahmadabad, founded by Sultan Ahmad Shah in the 15th century, on the eastern bank of the Sabarmati River, presents a rich architectural heritage from the sultanate period, notably the Bhadra citadel, the walls and gates of the Fort city and numerous mosques and tombs as well as important Hindu and Jain temples of later periods. The urban fabric is made up of densely-packed traditional houses (*pol*s) in gated traditional streets (*pur*as) with characteristic features such as bird feeders, public wells and religious institutions. The city continued to flourish as the capital of the State of Gujarat for six centuries, up to the present.



Plate 8: Entrance of Bhadra Fort, Aghmedabad

Outstanding Universal Value: Brief synthesis

The walled city of Ahmadabad was founded by Sultan Ahmad Shah in 1411 AD on the eastern bank of the Sabarmati River. It continued to flourish as the capital of the State of Gujarat for six centuries.

The old city is considered as an archaeological entity with its plotting which has largely survived over centuries. Its urban archaeology strengthens its historic significance on the basis of remains from the Pre-Sultanate and Sultanate periods.

The architecture of the Sultanate period monuments exhibits a unique fusion of the multicultural character of the historic city. This heritage is associated with the complementary traditions embodied in other religious buildings and the old city's very rich domestic wooden architecture with its distinctive "havelis" (neighbourhoods), "pols" (gated residential main streets), and khadkis (inner entrances to the pols) as the main constituents. These latter are presented as an expression of community organizational network, since they also constitute an integral component of the urban heritage of Ahmadabad.

The timber-based architecture of the historic city is of exceptional significance and is the most unique aspect of its heritage. It demonstrates Ahmadabad's significant contribution to cultural traditions, to arts and crafts, to the design of structures and the selection of materials, and to its links with myths and symbolism that emphasized its cultural connections with the occupants. The typology of the city's domestic architecture is presented and interpreted as an important example of regional architecture with a community-specific function and a family lifestyle that forms an important part of its heritage. The presence of institutions belonging to many religions (Hinduism, Islam, Buddhism, Jainism, Christianity, Zoroastrianism, Judaism) makes the historic urban structure of Ahmadabad an exceptional and unique example of multicultural coexistence.

Criterion (ii): The historic architecture of the city of the 15th century Sultanate period exhibited an important interchange of human values over its span of time which truly reflected the culture of the ruling migrant communities. The settlement planning was based on the respective tenets of human values and mutually accepted norms of community living and sharing. Its monumental buildings representative of the religious philosophy exemplified the best of the crafts and technology which saw growth of an important regional Sultanate architectural expression that is unparalleled in India. In order to establish their dominance in the region, the Sultanate rulers recycled the parts and elements of local religious buildings to reassemble those into building of mosques in the city. Many new mosques were also built in the manner of smaller edifices with maximum use of local craftsmen and masons, allowing them the full freedom to employ their indigenous craftsmanship. Therefore, the resultant architecture developed a unique provincial Sultanate idiom unknown in other parts of the subcontinent where local traditions and crafts were accepted in religious buildings of Islam, even if they did not strictly follow the tenets for Islamic religious buildings. The monuments of Sultanate period thus provide a unique phase of development of architecture and technology for monumental arts during the 15th century period of history of western India.

Criterion (v): Ahmadabad city's settlement planning in a hierarchy of living environment, with streets as also community spaces, is representative of the local wisdom and sense of strong community bondage. The house is a self-sufficient unit with its own provisions for water, sanitation and climatic control (the court yard as the focus). Its image and its conception with religious symbolism expressed through wood carving and canonical bearings is an ingenious example of habitat. This, when adopted by the community as an acceptable agreeable form, generated an entire settlement pattern with community needs expressed in its public spaces at the settlement level and

composed the self-sufficient gated street “pol”. Thus Ahmadabad’s settlement patterns of neighbouring close-packed pol provide an outstanding example of human habitation.

Integrity

Ahmadabad has evolved over a period of six centuries and has gone through successive periods of cyclic decay and growth. By and large the city still exudes wholeness and intactness in its fabric and urbanity and has absorbed changes and growth with its traditional resilience.

Conditions of integrity in the historic city, including topography and geomorphology, are still retained to a large degree. The hydrology and natural features have been subjected to changes due to progressive implementation of infrastructure by the local authorities. Its built environment, both historic and contemporary, has been also subjected to the changes and growth in terms of city’s population and community aspirations. Its infrastructure above and below ground also has been successively added and/or expanded as the need grew. Its open spaces and gardens, its land use patterns and spatial organization have largely remained unchanged as the footprints of earlier times have not been changed very much, perceptions and visual relationships (both internal and external); building heights and massing as well as all other elements of the urban character, fabric and structure have undergone change in most cases fitting within the existing historic limits and massing although some aberrations have occurred over a process of time.

Authenticity

The settlement architecture of Ahmadabad represents a strong sense of character of its conception through domestic buildings. The wooden architecture so prominently preferred is unique to the city. The entire settlement form is very ‘organic’ in its function considering its climatic response for year round comforts for the inhabitants.

The construction of the fort, the three gates at the end of the Maidan-e-Shahi and the Jama Masjid, with a large maidan on its north and south, were the first acts of Sultan Ahmed Shah to establish this Islamic town. On either side of the Maidan-e-Shahi and on the periphery around the Jama Masjid, the suburbs came up in succeeding phases of development.

The material used in construction of domestic building for all communities is composite with timber and brick masonry. Timber also provided a very good climatic comfort and humane quality in its usage. It also was a great unifying effect in developing harmonious living environment with significant elemental control of sizes in its building elements offering this harmonious quality.

The house form exhibited a very strong sense of an accepted type for organizing the plan with a central courtyard within the house irrespective of its overall size. The functions within were always typically organised around the courtyard or along it depending on the size of the house. This was essentially similar in all communities.

The concept of ‘Mahajan’ (nobility-guild) where all the people irrespective of their religious beliefs joined created a culture of society where there was a great sense of social wellbeing and of sharing. This was also observed in other prominent communities of Islamic and Hindu-Jain followers. The community bondage was the intrinsic duty of all people as a response to healthy co-existence. Markets were organized on this basis and all the merchants and traders became part of this, where individual interests were considered subsidiary to the collective ethics and morality. The culture shared thus also became an important source for encouraging exemplary enterprises in the city which

helped progressively evolve a city into a formidable place with industry and trade positioning it globally as a major centre.

Protection and management requirements

Ahmadabad includes 28 monuments listed by the Archaeological Survey of India (ASI), one monument listed by the State Department of Archaeology (SDA), and 2,696 important buildings protected by the Heritage Department at the Ahmadabad Municipal Corporation (AMC).

Monuments listed by the ASI enjoy legal protection at the national level via the Antiquities and Art Treasures Act, 1972, and the Ancient Monuments and Archaeological Sites and Remains Act, 1958, and Amendment & Validation Act, 2010 (AMASR). The monument listed by the SDA is of regional significance and is protected by AMASR.

The buildings and sites listed by the AMC (components of the walled historic city) are protected as a zone with special regulations by the development plan of Ahmadabad Urban Development Authority (AUDA).

The Heritage Department, AMC, as the nodal agency for heritage management in Ahmadabad, plays a leading role in the preparation of the Heritage Management Plan of the city. It has the support from all relevant administrative wings in the AMC, as well as authorities like the AUDA as well as ASI, Gujarat SDA and National Monuments Authority.

The Heritage Department at AMC should be enriched with capacity building and technical capacity relevant to the challenging size and extent of responsibilities of the documentation, conservation and monitoring of the city.

The proposed Heritage Management Plan is an important tool for the conservation and sustainable management of its cultural heritage of the city. The aim of the management plan is to ensure protection and enhancement of the Outstanding Universal Value of Historic City of Ahmadabad while promoting sustainable development using the Historic Urban Landscape approach. It aims at integrating cultural heritage conservation and sustainable urban development of historic areas as a key component of all decision-making processes at the city, agglomeration and larger territorial level.

The effective implementation of the Heritage Management Plan should be ensured together with the finalization, ratification and implementation of the modification and additions to the Development Control Regulations.

In order to complement the Heritage Management Plan, a visitor management plan for the city should be prepared, approved and implemented.

The Local Area Plan should be completed and implemented as part of the Heritage Conservation Plan, with a special focus on conservation of wooden historic houses.

A comprehensive and accurate documentation of the historic buildings of the property should be conducted, particularly the privately-owned timber houses, according to accepted international standards of documentation of historic buildings for conservation and management purposes.

A detailed assessment of the extent and impact of the new constructions and development projects on the western section of the city should be conducted.

Varanasi, a HRIDAY City

Varanasi city is situated in the north India and is also the administrative headquarters of the district of Varanasi in state of Uttar Pradesh. The city is situated on Western Bank of river Ganga. Throughout its history, the city has been known by a number of names: Anandvana (the forest of bliss); Kashi (the city of light); Banaras (a name derived from rivers Varuna and Asi that flow into Ganga), Benares and finally Varanasi. For a brief period, city was also named Mohammadabad by the Mughal King Aurangzeb. It is regarded as holy by Hindus, Buddhists and Jains and is one of the oldest continually inhabited cities in the world. to the Hindus, the city of Benares is the holiest place in the world, a sacred city and a place of pilgrimage.

Varanasi has been a centre of learning, enlightenment, culture and civilization for more than 3000 years. The city was located on the old trade route and was also mentioned by famous Chinese traveler Xuanzang. The culture of Varanasi is closely associated with river Ganga and the river's religious importance. People often refer to Varanasi as the city of temples, the holy city of India, the religious capital of India, the city of learning, culture capital of India et al.

The city was birth place of the famous Benares Gharana form of Indian classical music. The city was home to many prominent Indian philosophers, poets, writers and musicians, like Kabir, Ravi Dass, Munshi Prem Chand et al, to name a few. Tulsidas wrote his Ramacharitamans here, while Gautam Budha gave his first sermon at Sarnath (near Kashi). Ayurveda is also said to have originated here. The built heritage of the city comprises of numerous ghats on the bank of river Ganga (used for various purposes like bathing, rituals, cremating dead bodies et al); numerous temples (the most famous amongst which is Kashi Vishwanath, dedicated to Lord Shiva); the old city (marked by crowded narrow lanes flanked by road-side shops and scores of temples); palaces; stupas. Historically, Varanasi has been famous for muslin and silk fabrics (& its art of silk weaving), perfumes, ivory works and sculpture, textiles such as hand-woven carpets and handicrafts, brassware, copperware, glass bangles, wood and clay toys, musical instruments and exquisite gold jewellery.



Plate 9: Ganga Aarti in Varanasi

9.2.6 Comparative analysis

The sectors covered under JNNURM and the current missions overlap significantly. Water supply, sanitation, sewerage, SWM and storm water drainage appear to be top priorities across all missions. However, there is a difference in the approach to addressing these issues.

A major distinction between JNNURM and the current schemes is the scope of the mission components. JNNURM is a broad-based mission that simultaneously approaches various urban issues without prioritising outcomes. On the other hand, the new missions have opted for a more focussed

and sector-oriented approach. This is because they follow a set list of national priorities (universal access to water under AMRUT), advocate a specific approach and method (Greenfield development, retrofitting and redevelopment under SCM), or are devoted to a particular theme or issue (heritage conservation under HRIDAY and sanitation under SBM).

Further, while various urban sector components were earlier addressed through a single mission (JNNURM), these components have now been split across missions. For instance, AMRUT has prioritised water and sanitation over other objectives; SCM is committed to area specific urban renewal and redevelopment; SBM primarily addresses issues of hygiene, waste management, and public health; and HRIDAY is dedicated to the planned urban development of heritage cities.

The combined geographical coverage of the current missions is wider and more comprehensive than that of JNNURM. UIG and UIDSSMT together covered 736 cities and towns (where the 65 cities identified under UIG were chosen based on population). Under the new missions, almost all cities and towns of India are being covered under one or more missions. Further, city or town selection is more comprehensive under the new missions, as it is based on multiple evaluation criteria such as existing infrastructure, past performance (of JNNURM projects) and level of reform implementation, in addition to the urban population criterion mainly used under JNNURM. In particular, SCM has introduced a 'competitive city-selection' format, wherein cities will be selected only after passing two rigorous evaluation rounds, with achievements under JNNURM being one of the selection criteria.

The new missions are also complementary to each other and encourage states to access the funds available under different missions to address their deficits. For instance, AMRUT and SCM have overlapping sectors but different focus areas and approaches. Cities can first develop their core infrastructure under AMRUT and then choose specific areas for development under SCM. In due course, the city can replicate its successful area-based development strategies in other areas. Similarly, HRIDAY cities can access AMRUT for city-level infrastructure needs such as water and sanitation facilities but use HRIDAY funds to support infrastructure projects which link heritage facilities with their trunk infrastructure.

In addition, the new missions have introduced some changes based on the learning from JNNURM. For example, delayed availability and/or non-availability of land and clearances from the concerned departments have been a major reason for project delays under JNNURM. Hence, AMRUT prescribes that only projects which have obtained clearances from the required departments and have ensured land availability will be eligible for funding under AMRUT. Further, unlike the project-to-project sanctions provided under JNNURM, AMRUT emphasises 'cooperative federalism' by making states equal partners in the planning and implementation of projects. Thus, states have been given a bigger role in decision-making and sanctioning of projects under the new missions.

9.3 Rural-Urban Continuum (RURBAN)

Conventionally, rural-urban continuum proposes a linear depiction of the contrasting natures of social relationships characteristic of rural and urban settlements. This was a popular conceptual tool to classify different types of community and the transition between them. It arose from early 20th century sociology attempting to understand the social changes consequent upon rapid urbanization. Life in the countryside occurred in small, geographically isolated settlements which were socially homogeneous, with high levels of mutual communication and social solidarity, and which changed very slowly. Urban communities were attributed the opposite characteristics: L. Louis Wirth of the Chicago School, in his highly influential essay 'Urbanism as a Way of Life' (American Journal of Sociology, 1938), thought cities distinctive because they were large, dense and heterogeneous and that this produced the transient, disorderly, anonymous and formal associational relationships of urban living.

Such understandings had affinities with Ferdinand Tonnies' a-spatial distinction between *gemeinschaft* (community) and *gesellschaft* (association). In principle, if all settlements could be placed on such a continuum we would have a strong account of spatial arrangement influenced social life. Some sociologists have used the concept of rural-urban continuum to stress the idea that there are no sharp breaking points to be found in the degree or quantity of rural-urban differences. Robert Redfield has given the concept of rural -urban continuum on the basis of his study of Mexican peasants of Tepoztlain. The rapid process of urbanization through the establishment of industries, urban traits and facilities has decreased the differences between villages and cities. There are some sociologists who treat rural-urban as dichotomous categories have differentiated the two at various levels including occupational differences, environmental differences, differences in the sizes of communities, differences in the density of population, differences in social mobility and direction of migration, differences in social stratification and in the systems of social interaction. Another view regarding rural and urban communities has been given by Pocock who believe that both village and city are elements of the same civilization and hence neither rural-urban dichotomy, nor continuum is meaningful.

M. S. A. Rao points out in the Indian context that although both village and town formed part of the same civilization characterized by institution of kinship and caste system in pre-British India, there were certain specific institutional forms and organizational ways distinguishing social and cultural life in towns form that in village.

G. S. Ghurye believes that urbanization is migration of people from village to city and the impact it has on the migrants and their families. There is no sharp demarcation to tell where the city ends and country begins. Every village possesses some elements of the city and every city carries some features of the village.

Ramkrishna Mukherjee prefers the continuum model by talking of the degree of urbanization as a useful conceptual tool for understanding rural-urban relations. P. A. Sorokin and Zimmerman, in 'Principles of Rural-Urban Sociology', have stated that the factors distinguishing rural from urban communities include occupation, size and density of population as well as mobility, differentiation and stratification. However, subsequent research largely undermined that idea.

Spatial arrangements themselves are not determinant of social relations; even if some parts of cities are rather anarchic, more, for instance the suburbs, do not conform to the model. One can also find traditional and interpersonally intimate relationships in cities, as exemplified by the working class community of Bethnal Green by Michael Young, and conflicts and isolation in the countryside. Moreover, both city and village contain culturally distinct groups, suggesting that there are no dominant cultural forms typical of settlement type and that settlement type does not determine the character of interpersonal social ties.

Thus, the rural-urban continuum may be defined as a dynamic equilibrium wherein the development process involves the people in both rural and urban areas and the returns of development are also distributed to the people whose settlement pattern is distributed spatially.



9.3.1 Dynamic Characteristics of Continuum

The dynamic characteristics of rural urban continuum are directly made on the following relations:

a) Agricultural Relations

Near the urban centres the intensity of agricultural activities is generally high, and this tendency is decreased with the increasing distance towards peripheral areas.

b) Business and Financial Relations

Wholesale trade and other trade related services located in urban centres develop relation between the urban and rural areas.

c) Educational and Health Relations

The urban centres generally have educational centres in the form of schools, college, technical schools and sometimes post graduate level educations. People from rural areas come to urban areas and make a relationship. Relationship also develops for providing health facility to the surrounding villages.

d) Transport and Communication Relations

Urban centres act as a convergence point for different modes of transport routes. Urban centres are connected with transport and communication with the neighbouring villages. Urban centres also act as nerve centres, of transportation lines. Roads radiate like spokes of a wheel in different directions from the city centres. So, a relationship is developed between urban and rural areas.

e) Administrative and Political Relations

Urban centres may act as a place of state capital, district headquarter, sub-divisional headquarters. These centres pull people every day from surrounding areas and create relation between rural and urban areas. Urban centres are the centres of political party offices. People also come to urban areas for political reasons.

f) Social and Cultural Relations

Cultural functions, religions festivals, sports and games fall under social and cultural items of entertainment which are mostly undertaken in urban areas. People both from urban and rural areas take part and establish social and cultural relations.

g) Industrial Relations

Industries are mostly located in urban areas or at the periphery of urban areas. But they receive raw materials from rural areas and labourers from both urban areas and surrounding areas.

h) Mobility Patterns

Daily movement establishes a mutual relationship between rural and urban areas. The zone or belt, where commuters move is known as commuter belt.

10.0 Conclusion

This group of Self-Learning Material has made the fundamental concepts of settlement geography clear. It has presented the science of ekistics, the difference between urban and rural in Indian context, the types and patterns of rural settlements, different hierarchies of urban settlements etc. Besides doing this, it has also elaborated few commonly used terminologies such as mega city, megalopolis, ecumenopolis, metropolis, urban sprawl, urban renewal programmes etc. This is followed by the questions prepared from this SLM.

11.0 Self-assessment Tests

- a) Explain the term ekistics.
- b) Why a fair is not considered as a settlement?
- c) How will you define an Indian settlement to be urban?
- d) What are the distinctions between an urban and a rural place?
- e) Explain the rank-size rule as has been proposed by G.K. Zipf. Write the applicability of this theory in Indian context.
- f) Define threshold population. Explain Christaller's Central Place Theory. Evaluate this theory in the present light of settlement orderliness.
- g) What are the different types and patterns of rural settlements? Explain with suitable figures.
- h) Explain the concept of rural-urban continuum.
- i) Present the characteristics of metropolitan city.
- j) Define mega city.
- k) What are the different factors for urbanisation?
- l) Write a short note on JNNURM.
- m) What do you mean by heritage city?
- n) Bring out the major causes of urban sprawling. Explain its effects on both the urban and rural area.
- o) Who proposed the concept of ecumenopolis? Connote the concept of ecumenopolis.
- p) What do you mean by a census town? Explain the role of census towns in Indian urbanization in 2011.
- q) Write in brief the history of Indian urbanization since the Independence.
- r) What are the characteristics of a smart city?
- s) What do you mean by green city?

- t) Write the role of Swachh Bharat Mission in the urban renewal programme of Indian cities.
- u) Explain the concept of primate city in the light of Indian urbanization.
- v) Assess the role of Swachh Bharat Mission in maintaining the urban renewal mission.

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Post-Graduate Degree Programme (CBCS)
in
GEOGRAPHY

Semester-II

Paper: GEO207T

Self-Learning Material



DIRECTORATE OF OPEN AND DISTANCE LEARNING
UNIVERSITY OF KALYANI
Kalyani, Nadia
West Bengal, India

COURSE MATERIAL COMPILED BY

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GEO207T.1:
Environmental Issues
in Geography

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University of Kalyani

GEO207T.2:
Geography of
Resources and Hazards

June, 2019

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Director's Message

Satisfying the varied needs of distance learners, overcoming the obstacle of distance and reaching the unreached students are the threefold functions catered by Open and Distance Learning (ODL) systems. The onus lies on writers, editors, production professionals and other personnel involved in the process to overcome the challenges inherent to curriculum design and production of relevant Self Learning Materials (SLMs). At the University of Kalyani a dedicated team under the able guidance of the Hon'ble Vice-Chancellor has invested its best efforts, professionally and in keeping with the demands of Post Graduate CBCS Programmes in Distance Mode to devise a self-sufficient curriculum for each course offered by the Directorate of Open and Distance Learning (DODL), University of Kalyani.

Development of printed SLMs for students admitted to the DODL within a limited time to cater to the academic requirements of the Course as per standards set by Distance Education Bureau of the University Grants Commission, New Delhi, India under Open and Distance Mode UGC Regulations, 2017 had been our endeavour. We are happy to have achieved our goal.

Utmost care and precision have been ensured in the development of the SLMs, making them useful to the learners, besides avoiding errors as far as practicable. Further suggestions from the stakeholders in this would be welcome.

During the production-process of the SLMs, the team continuously received positive stimulations and feedback from Professor (Dr.) Sankar Kumar Ghosh, Hon'ble Vice- Chancellor, University of Kalyani, who kindly accorded directions, encouragements and suggestions, offered constructive criticism to develop it within proper requirements. We gracefully, acknowledge his inspiration and guidance.

Sincere gratitude is due to the respective chairpersons as well as each and every member of PGBOS (DODL), University of Kalyani. Heartfelt thanks is also due to the Course Writers-faculty members at the DODL, subject-experts serving at University Post Graduate departments and also to the authors and academicians whose academic contributions have enriched the SLMs. We humbly acknowledge their valuable academic contributions. I would especially like to convey gratitude to all other University dignitaries and personnel involved either at the conceptual or operational level of the DODL of University of Kalyani.

Their persistent and co-ordinated efforts have resulted in the compilation of comprehensive, learner-friendly, flexible texts that meet the curriculum requirements of the Post Graduate Programme through Distance Mode.

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Director
Directorate of Open and Distance Learning
University of Kalyani

SYLLABUS

SEMESTER-II

Paper – GEO207T

**Paper–GEO207T (Total Credit–4; Total Marks–100:
Internal Evaluation–20, Semester-end Examination–80)**

GROUP–GEO207T.1: ENVIRONMENTAL ISSUES IN GEOGRAPHY

(Credit – 2; Marks - 50: Internal Evaluation – 10 + Semester-end Examination - 40)

- Unit-1: Concept of resource-population relationship
- Unit-2: Types and significance of worldwide contemporary major environmental issues
- Unit-3: Concept of ecological foot print; Sustainable development
- Unit-4: Role of IUCN, UNDP, UNEP, IPCC and UNFCCC
- Unit-5: Concept of participatory management of forest: Agro forestry, Social forestry and JFM
- Unit-6: Wildlife conservation and management: Sanctuaries, National Parks and Biosphere Reserves w.r.t. India
- Unit-7: Dams and development—displacement and rehabilitation issues; Environmental implications of River Linking Project
- Unit-8: Dimensions of environmental movements in India

GROUP–GEO207T.2: GEOGRAPHY OF RESOURCES AND HAZARDS

(Credit – 2; Marks - 50: Internal Evaluation – 10 + Semester-end Examination - 40)

- Unit-9: Concept and types of hazards and disasters
- Unit-10: Assessment of risk and vulnerability
- Unit-11: Concepts of hazard and disaster management
- Unit-12: Climatic hazards: Tropical cyclones (prediction, precaution and mitigation)
- Unit-13: Marine/tectonic hazard: Tsunami (prediction, precaution and mitigation)
- Unit-14: Hydrological hazards: Flash floods in Himalayan region and floods in southern part of West Bengal
- Unit-15: Sources, impacts and mitigation measures of nuclear hazard and radio-active contamination, CFC and plastic hazard
- Unit-16: Sources, impacts and mitigation measures of lead, arsenic and fluoride contaminations

Mode of Internal Examination: Multiple Choice Type Questions

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GROUP: GEO207T.1

ENVIRONMENTAL ISSUES IN GEOGRAPHY

(Credit – 2; Marks - 50: Internal Evaluation – 10 + Semester-end Examination - 40)

1.1 Introduction

The term environment etymologically means surrounding. Thus the entire natural features, social and cultural aspects which encircle us, are collectively known as environment. It is the particular branch of geography that describes and explains the spatial aspects of interactions between human individuals or societies and their natural environment. Environmental geography represents a critically important set of analytical tools for assessing the impact of human presence on the environment by measuring the result of human activity on natural landforms and cycles.

The links between human and physical geography were once more apparent than they are today. As human experience of the world is increasingly mediated by technology, the relationships between humans and the environment have often become obscured. Thereby, environmental geography represents a critically important set of analytical tools for assessing the impact of human presence on the environment. This is done by measuring the result of human activity on natural landforms and cycles.

1.2 Learning Objectives

After reading this group on Environmental Issues in Geography, the learners will be able to

- Conceptualize the resource-population relationship,
- Know the types and significance of worldwide contemporary major environmental issues;
- Conceptualize the ecological foot print, Sustainable development;
- Explain the role of IUCN, UNDP, UNEP, IPCC and UNFCCC;
- Explain the concept of participatory management of forest
- Differentiate between Agro forestry, Social forestry and JFM;
- Know the objectives of wildlife conservation and its different ways of management
- Capitulatethe differential objectives of Sanctuaries, National Parks and Biosphere Reserves with particular reference to India
- Explain the issues of dams and development – displacement and rehabilitation
- Interpret the environmental implications of River Linking Project
- Know the dimensions of environmental movements in India

1.3 Assessment of Prior Knowledge

To assess the students' prior knowledge, they may be asked

- What do you mean by environment?
- What are the major environmental issues at present?
- What is resource?
- What is ecology?
- What is biodiversity?
- What are the causes of loss of biodiversity?

1.4 Learning Activities

During the Personal Contact Programmes, students may be assigned to prepare several short projects on different issues such as Joint Forest Management of West Bengal, dams and displacement, environmental movements, wildlife protection etc. Internal assessment in the form of questions may also be given. Preparation of charts and models on different aspects may also be assigned.

1.5 Feedback of Learning Activities

The feedback of learning may be assessed through internal assessment, demonstration, power-point presentation, group discussion, debate, quiz and examination on the relevant aspects.

2.0 Concept of Resource-Population Relationship

2.1 Introduction

Size, distribution and population structure within a country must be viewed in relation to its natural resources and the techniques of production used by its population. In population-resource relation, we need to consider the complex as well as dynamic linkages of capability opportunity-propensity matrix of different human groups and their individual members separately, inhabiting presently and also will inhabit in future in different regions of the world.

Before learning the population-resource relationship, we should understand the concept of carrying capacity. Carrying capacity is the total number of individuals that a region can support at a given point of time. It differs from space to space and from time to time. It depends upon the resource base of an area as well as the state of technology. In Nature, all substances stay as neutral staff. When these neutral staffs fulfil some human needs, these are called resources. This conversion of neutral staff into resources largely depends on the technological achievement of a nation. Thus with the advancement of science and technology, the concept of population-resource relation may change over time.

2.2 Concept of Over-Population

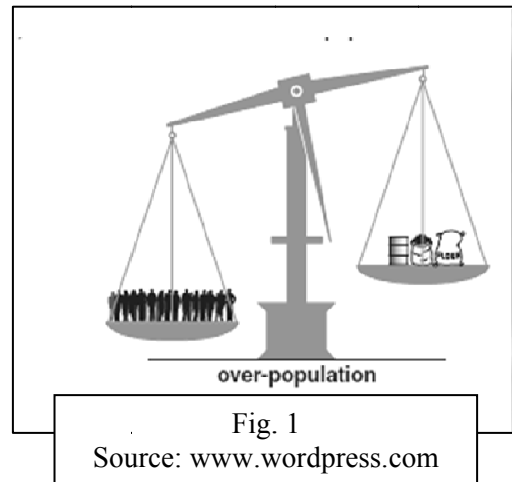
The term 'overpopulation' means too great a population for a given region to support in comparison to its resource supply. There may be two causes for over-population:

- (i) Population growth exceeds the existing resource base;
- (ii) Existing resources have been depleted.

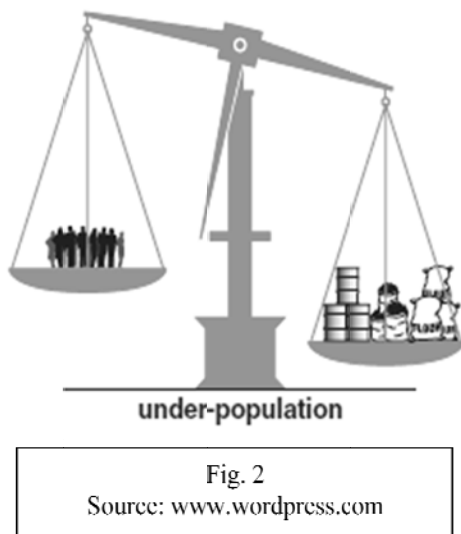
Some authors distinguish absolute overpopulation (where the absolute limit of production has been attained but standards of living remain low) from relative overpopulation (where present production does not support the population but the production can be augmented). The situation of over-population has the following outcomes:

- Large scale unemployment
- Low per capita income,
- Low standards of living,
- High population density,
- malnutrition and famine,
- High dependency ratio,
- High agricultural density,
- Depletion of natural resources, especially fossil fuels,
- Increased rate of pollution,
- Elevated crime rate etc.

Example – the present population scenario of India, Bangladesh, Pakistan etc.



2.3 Concept of Under-population



Under population exists when a population is too small, therefore unable to fully utilise the available resource endowments. Under population is also characterised by a situation where the available resources are capable of supporting a much larger population with no reduction in living standards.

Relative under population is more common than absolute under population. Indeed, absolute under population is rarely seen and may be found in completely secluded societies where, the degree of replacement of population is less than unity. Relative under population occurs due to insufficient resource development. In developed economies, rural under population is more visible, whereas in backward countries, under population is linked to high mortality rate.

Example – The current population scenario of Switzerland, Sweden, Norway, Denmark etc.

2.4 Concept of Optimum population

Optimum population has been defined as that size of population enabling per capita output of the maximum orders accompanied by the highest possible standards of living under a given set of economic and technological conditions. Therefore, optimum population lies between two extremes, i.e., overpopulation and under-population, although the size of optimum population is not sacrosanct.

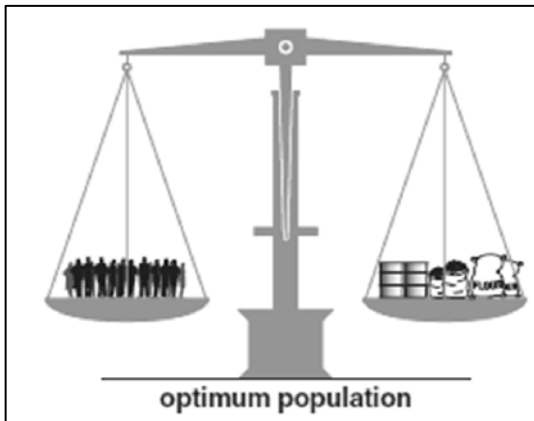


Fig. 3
<https://sites.google.com/site/>

It is a theoretically perfect situation difficult to estimate or define. The Penguin Dictionary of Geography characterises optimum population as a situation when the number of individuals can be accommodated in an area to the maximum advantage of each individual.

Thus optimum population yields highest quality of life, which means each person has access to adequate food, water, energy and air of highest quality, adequate medical care, recreational facilities and cultural outlets. In other words, optimum population permits the highest per capita output; therefore the marginal productivity exceeds the average productivity whereby the rates of growth of total production are the highest.

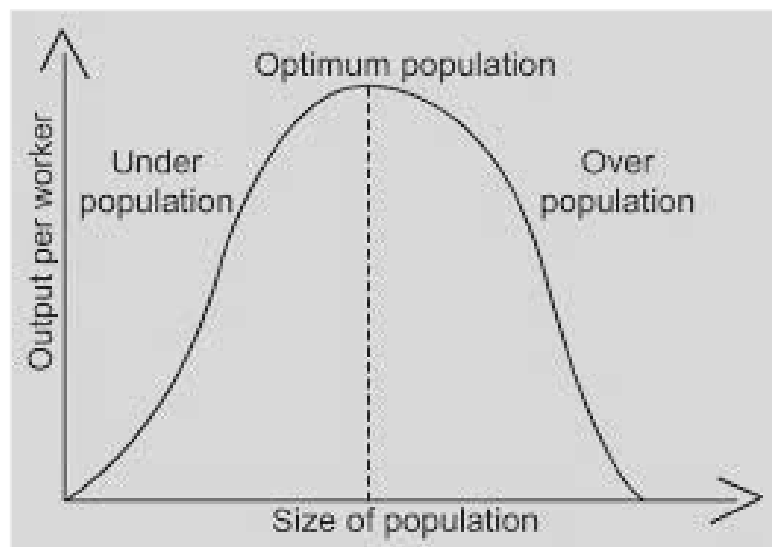


Figure 4: Concept of Over-population, Under-population and Optimum Population

Source: accessed from <http://www.economicdiscussion.net/>

2.5 Population-Resource Regions

Edward Augustus Ackerman (Idaho 1911- Washington 1973) was a noted American geographer and an authority in the management of hydric resources in US. He was member of several committees and advisory groups on management of natural resources, population growth, the environment and conservation. Through his career, he placed emphasis on the need of a sustainable management of the natural resources. A key element of Ackerman's thinking is the concept of system and the interactions between the people and the nature. According to Ackerman, 'the objective of Geography is to understand the great system that encompasses the humanity and its environment on Earth's surface'.

Edward A. Ackerman has used three basic criteria for devising the world's regional scheme of population /resource ratio, which are:

- Population factor,
- Resource factor and
- Technology factor

Among these three variables used in this scheme, the most critical is the magnitude and quality of available technology. Ackerman while using the three factors of population, resource and technology, emphasized more on technology. He suggested a five-fold classification of the world into population/resource regions on the basis of population resource ratios and the availability of technology:

A) **United States Type:** About one sixth of the world's people live in technology-source areas with low population/resource ratios, as in much of North America, Australia and New Zealand and the erstwhile Soviet Union. These regions, by virtue of their extensive territories and resources, are able to create lofty social and economic estate within their own territory. Here high standards of economic lives are prevalent.

B) **European Type:** One sixth lives in technology-source areas with high population/resource ratios, where industrialization and technology have permitted an expansion of resources through international trade. Most of Europe and Japan fall in this category. It has smaller territory and larger population compared to USA type. The smaller territories coupled with larger population produce intensive economy with conservative attitude. The prosperity of these regions depends on the international exchange of goods, ideas, innovations, skills etc. In this region, a competitive attitude as well as a struggle for existence is observed. The emigration policy, colonisation are the means of stabilisation of economy in these regions.

C) **Brazilian Type:** One sixth live in technology-deficient areas with low population/resource ratios, as in much of Latin America, Africa and South-East Asia, where resources sometimes remain unused because of the problems of developing difficult environments. Population size is well below the level. Due to poor technology, most of the abundant natural resources cannot be harnessed in these regions.

D) **Egyptian or China Type:** Roughly one half live in areas which are technology-deficient with high population/resource ratios, as in India, Pakistan and China. This type epitomizes some of the most severe population problems. Population pressure is very high in relation to existing resource base. Mass illiteracy exists. Mainstay of economy is agriculture. Per capita income is also very low.

E) **Arctic Desert Type:** The largely uninhabited ice caps, tundra's and deserts are mostly technology-deficient and offer little food-producing potential at the moment. Few resources are abundant but due to poor technology and adverse climatic conditions, these resources are not utilized. Population is very sparse.

This classification is a useful general guide but offers little help for more specific cases of pressure of population on resources, which is extremely difficult to define in quantitative terms due to the dynamism of the variables involved: population, resource, technology and the economic expectations and attainments of the people.

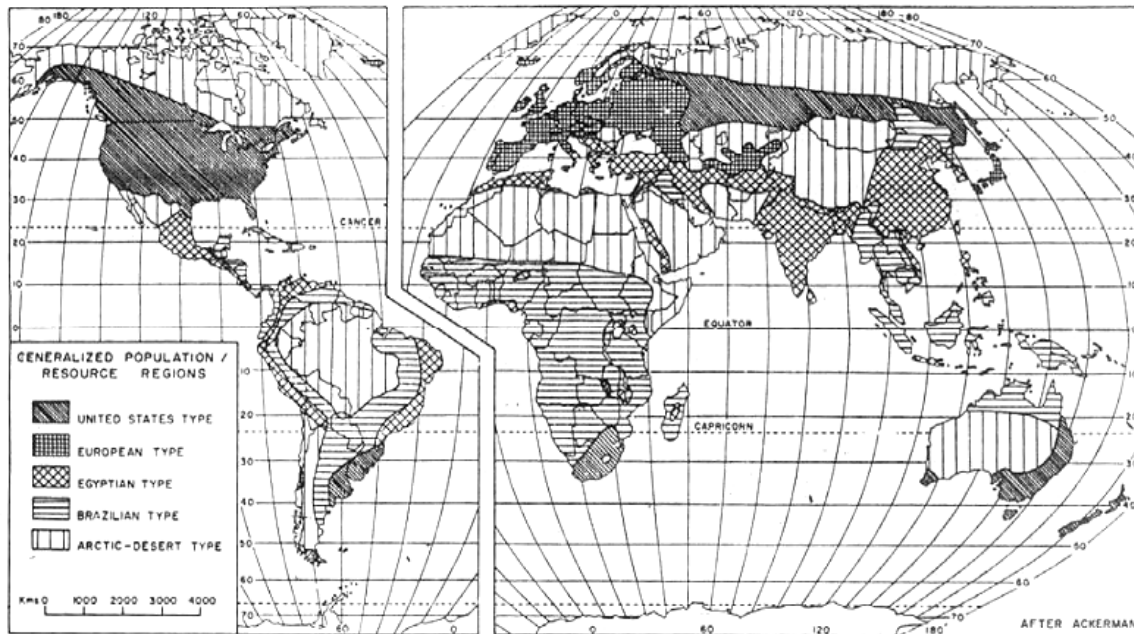


Figure 5 : Population-Resource Regions of the World by Ackerman
Source: Ackerman, 1967

3.0 Types and Significance of Worldwide Contemporary Major Environmental Issues

Increased human activity, urbanization, industrialization have led to rapid deterioration of the environment. This has severely affected the life supporting system. The developmental discrepancies in different regions of the world pose a serious threat to our common global environment. Consequently, we are confronted with complex environmental issues deserving attention. Few important global environmental issues are:

- Greenhouse effect and global warming
- Biodiversity loss
- Depletion of ozone layer
- Acid rain
- Dumping of hazardous wastes

3.1 Greenhouse Effect and Global Warming

Weather and climate have a profound impact on living organisms of this planet. Ecological systems have evolved over geological time scales to suit the prevailing climate. The past 10 to 20 years have brought disturbing evidence that human activities may cause significant changes in future global climate. 'Global Warming' is now an issue known to hundreds of millions of people across the globe.

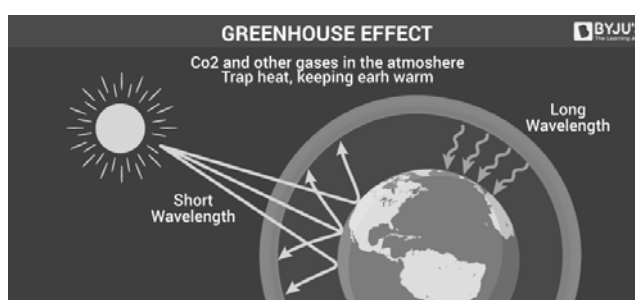
Climate change is not a new phenomenon in the Earth's history. The geological record shows that when viewed over a time scale of thousands of years, the climate is in a state of more or less continual change with major ice ages occurring approximately every 100,000 years. Regular occurrence of ice ages has an astronomical origin associated with subtle changes in the separation and relative orientation of the Earth and the Sun. However, the recent change in atmospheric temperature has brought concerns for all. There has been an abrupt increase of temperature associated with retreat of glaciers.

3.1.1 The Greenhouse Effect

A green house is a glass chamber in which plants are grown to provide them warmth by trapping the sunlight. Sunlight (a form of energy) passes through the glass and it gets absorbed inside. Unlike sunlight, heat radiation cannot escape through glass. The heat generated there from, cannot escape out of the glass chamber. Thus, even on a cold winter day, the inside of a greenhouse can become quite warm to support plant growth. The phenomenon of heat build-up inside a glass chamber from the absorption of solar radiation is called greenhouse effect.

The green-house effect is a natural phenomenon and has been occurring for millions of years on the earth. Life on the earth has been possible because of this natural greenhouse effect which is due to water vapour and small particles of water present in the atmosphere. Together, these produce more than 95 per cent of total green-house warming. An average global temperature is maintained at about 15°C due to natural greenhouse effect. Without this phenomenon, average global temperatures might have been around -17°C and at such low temperature, life would not be able to exist.

The history of the scientific understanding of the greenhouse effect can be traced back to Jean Baptiste-Joseph de Fourier in 1827. Fourier suggested that the atmosphere allows short wavelength radiation from the Sun to reach and warm the Earth's surface but blocks emission of longer wavelength radiation which would cool the Earth. Fourier compared this effect to that of the glass in a greenhouse (hence "greenhouse effect") predicted that climate could be influenced by human activities. It is now known that prevention of the loss of warm air via convection is the main factor by which heat is retained in a greenhouse. However, for historical reasons, the terms "greenhouse effect" and "greenhouse gases" are still used when describing radiative trapping of heat in the atmosphere. In 1859, John Tyndall measured the infra-red (heat) trapping ability of water vapour, carbon dioxide, and methane and suggested that ice ages were caused by variations of the atmospheric levels of these gases.



Plates 1 and 2 : Glasshouse and Greenhouse Effect of the Atmosphere

3.1.2 Greenhouse Gases

The three most powerful long lived greenhouse gases in the atmosphere are carbon dioxide, methane, and nitrous oxide. In addition, halogenated organic compounds (of which CFCs are a subset), SF₆, and ozone in the lower and upper atmosphere also cause greenhouse effect. At this point, it is germane to note that water vapour is the single most powerful greenhouse gas in the atmosphere. Water vapour has approximately twice the effect of the second most powerful greenhouse gas—carbon dioxide. Human activities do not have any significant direct impact on the level of water vapour in the atmosphere. However, as a result of global warming, it is likely that human activities will have a significant indirect impact on the level of water vapour in the atmosphere.

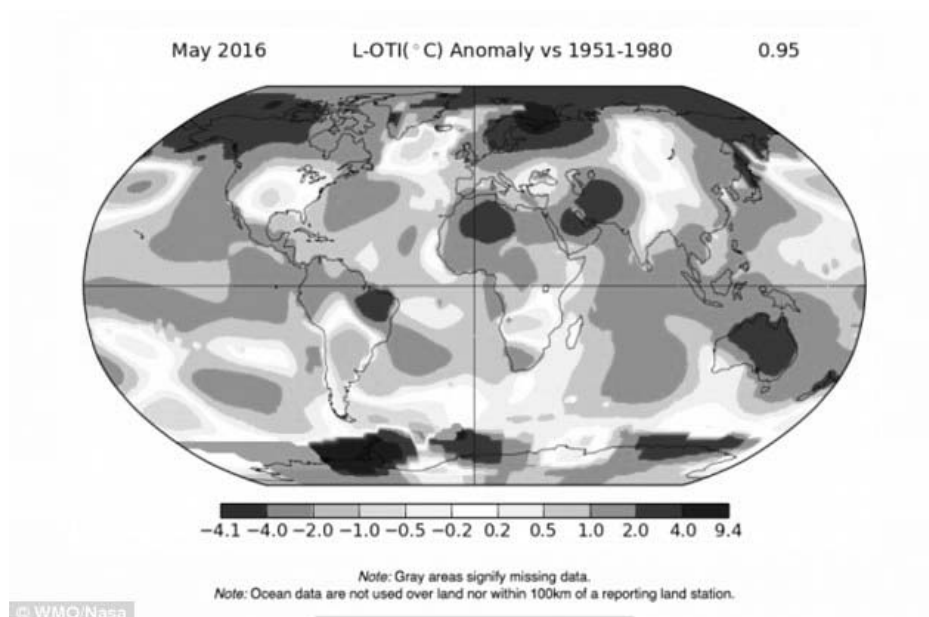
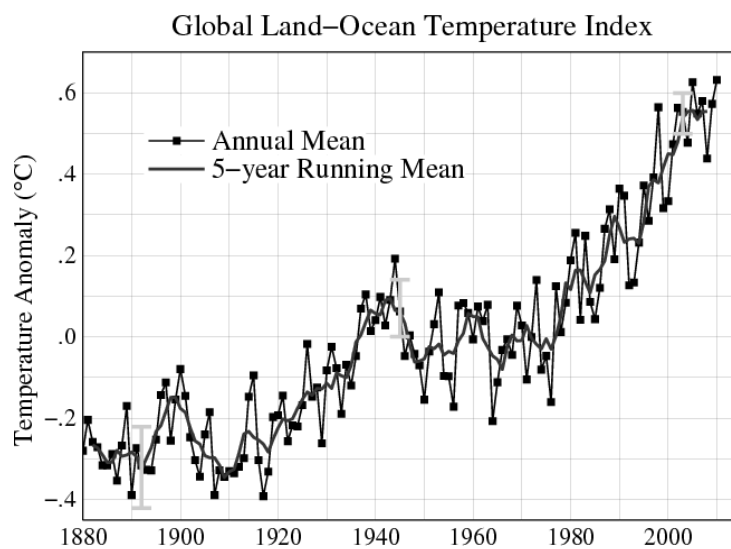
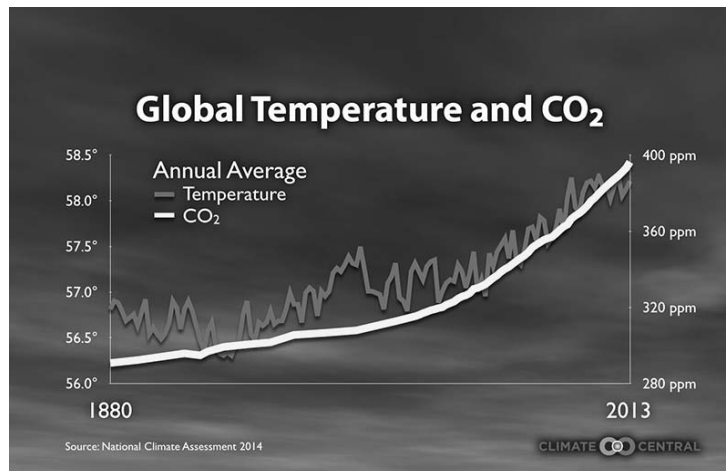
3.1.3 Greenhouse Effect and Global Warming

Given the size and tremendous heat capacity of the global oceans, it takes a massive amount of accumulated heat energy to raise Earth's average yearly surface temperature even a small amount. Behind the seemingly small increase in global average surface temperature over the past century is a significant increase in accumulated heat. That extra heat is driving regional and seasonal temperature extremes, reducing snow cover and sea ice, intensifying heavy rainfall, and changing habitat ranges for plants and animals—expanding some and shrinking others.

The concept of an average temperature for the entire globe may seem odd. After all, at this very moment, the highest and lowest temperatures on the Earth are likely more than 100°F (55°C) apart. Temperatures vary from night to day and between seasonal extremes in the Northern and Southern Hemispheres. This means that some parts of the Earth are quite cold while other parts are downright hot. To speak of the "average" temperature, then, may seem like nonsense. However, the concept of a global average temperature is convenient for detecting and tracking changes in Earth's energy budget—how much the sunlight Earth absorbs minus how much it radiates to space as heat—over time.

Though warming has not been uniform across the planet, the upward trend in the globally averaged temperature shows that more areas are warming than cooling. Since 1901, the planet's surface has warmed by 0.7–0.9° Celsius (1.3–1.6° Fahrenheit) per century, but the rate of warming has nearly doubled since 1975 to 1.5–1.8° Celsius (2.7–3.2° Fahrenheit) per century, according to the international State of the Climate in 2017 report.

The 10 warmest years on record have all occurred since 1998, and the four warmest years on record have all occurred since 2014. Looking back to 1988, a pattern emerges: except for 2011, as each new year is added to the history, it becomes one of the top 10 warmest on record at that time, but it is ultimately replaced as the “top ten” window shifts forward in time.



3.1.4 Effects of Global Warming

- Rising Temperature

The planet's average surface temperature has risen about 1.62 degrees Fahrenheit (0.9 degrees Celsius) since the late 19th century, a change driven largely by increased carbon dioxide and other human-made emissions into the atmosphere. Most of the warming occurred in the past 35 years, with the five warmest years on record taking place since 2010. Not only was 2016 the warmest year on record, but eight of the 12 months that make up the year — from January through September, with the exception of June — were the warmest on record for those respective months.

- Rising seas and coastal floods

Global sea level rose about 8 inches in the last century. The rate in the last two decades, however, is nearly double that of the last century and is accelerating slightly every year. Rising sea levels and more frequent and intense storm surges will see more erosion of coastline, wearing away and inundating community and residential properties.

- Retreating glaciers

Glaciers are retreating almost everywhere around the world — including in the Alps, Himalayas, Andes, Rockies, Alaska and Africa. The Greenland and Antarctic ice sheets have decreased in mass. Data from NASA's Gravity Recovery and Climate Experiment show Greenland lost an average of 286 billion tons of ice per year between 1993 and 2016, while Antarctica lost about 127 billion tons of ice per year during the same time period. The rate of Antarctica ice mass loss has tripled in the last decade.

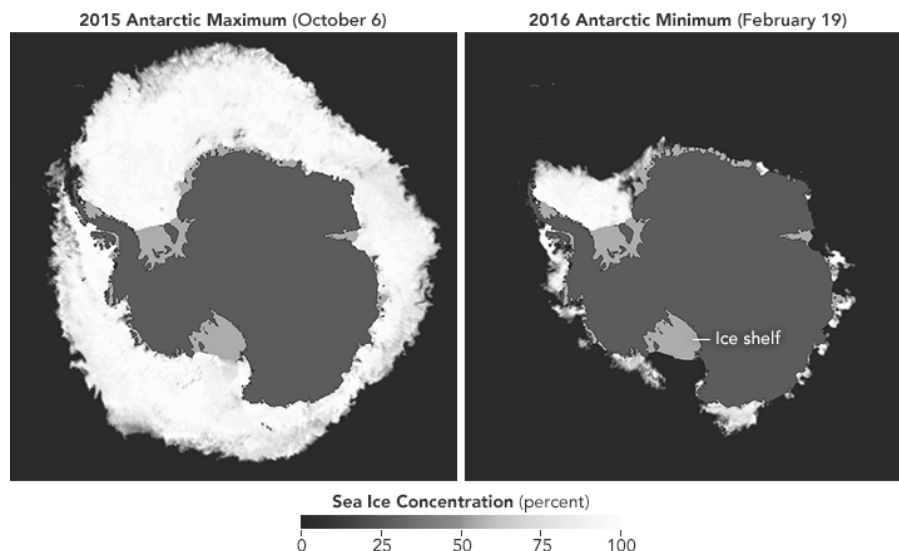


Plate 3 : Decreasing Ice-cover in Antarctica

- Longer and more damaging wildfire

As a result of global climate change, many areas around the world will be more prone to increased wildfire activity. Wildfires will become more frequent, burn more intensely, and will burn larger

areas; additionally, fire seasons (time periods during which fire is most active) will, in many cases, be observed for longer durations annually.

- More intensive heat wave

Global climate change is almost certain to increase the frequency and intensity of heat waves. Over the last fifty years we have seen an increase in heat wave events, an increase scientists believe is the result, at least in part, of human activity.' The recently released Fourth Assessment of the Intergovernmental Panel on Climate Change (IPCC) concludes that heat waves will "very likely" increase over most land areas over the course of this century.

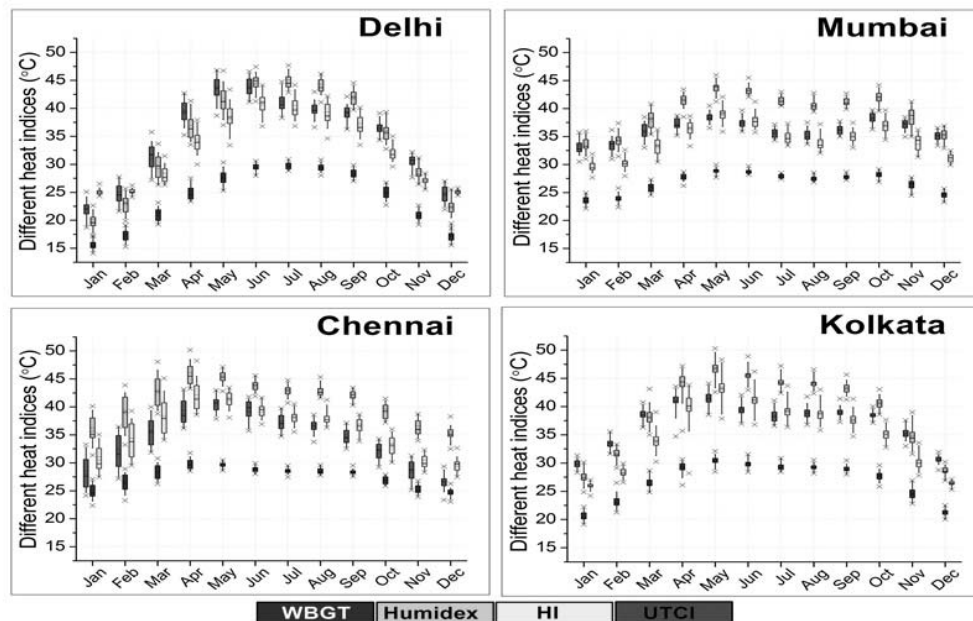


Figure 4: Annual cycles of the four heat indices based on monthly mean values of IMD station data for the period 1975-2005.

Figure 9 : Heat wave in Indian Cities

- Extreme weather phenomena

The number of record high temperature events throughout the world has been increasing, while the number of recorded low temperature events has been decreasing, since 1950. The U.S. has also witnessed increasing numbers of intense rainfall events.

- Extinction of many existing species

One in six species is at risk of extinction because of climate change. To survive, plants, animals and birds confronted with climate change have two options: move or adapt. With the speed of climate change we are experiencing already, it's often not possible for a species to adapt quickly enough to keep up with its changing environment. And with the amount of habitat destruction, moving is becoming increasingly difficult.

- Genesis of new virus and diseases

Higher temperatures and humidity could produce more mosquito-borne disease. The damaging effects of climate change are already in evidence in every corner of the planet and children are already

suffering most from its myriad impacts. Not only do children make up almost half of the population in developing countries, but they are also especially vulnerable to its impacts.

- Destruction of marine resources

Rising temperatures and acidity within our oceans is contributing to extreme coral bleaching events, like the 2016 event that destroyed more than one-third of the Great Barrier Reef.

- Lowering of Groundwater Table

Climate change poses uncertainties to the supply and management of water resources. The Intergovernmental Panel on Climate Change (IPCC) estimates that the global mean surface temperature has increased 0.6 ± 0.2 °C since 1861, and predicts an increase of 2 to 4 °C over the next 100 years. Temperature increases also affect the hydrological cycle by directly increasing evaporation of available surface water and vegetation transpiration. Consequently, these changes can influence precipitation amounts, timings and intensity rates, and indirectly impact the flux and storage of water in surface and subsurface reservoirs (i.e., soil moisture, ground water etc.). In addition, there may be other associated impacts, such as sea water intrusion, water quality deterioration, potable water shortage, etc. While climate change affects surface water resources directly through changes in the major long-term climate variables such as air temperature, precipitation, and evapotranspiration, the relationship between the changing climate variables and groundwater is more complicated and poorly understood.

The greater variability in rainfall could mean more frequent and prolonged periods of high or low groundwater levels, and saline intrusion in coastal aquifers due to sea level rise and resource reduction. Groundwater resources are related to climate change through the direct interaction with surface water resources, such as lakes and rivers, and indirectly through the recharge process. The direct effect of climate change on groundwater resources depends upon the change in the volume and distribution of groundwater recharge.

- Salinization and Desertification

Carbon dioxide-induced climate change and desertification remain inextricably linked because of feedbacks between land degradation and precipitation. Water resources are inextricably linked with climate. Annual average river runoff and water availability are projected to increase by 10-40% at high latitudes and in some wet tropical areas; and decrease by 10-30% over some dry regions at mid-latitudes and in the dry tropics. Soils exposed to degradation as a result of poor land management could become infertile as a result of climate change.

- Reduced Agricultural Production

Extreme weather, as well as average temperature and rainfall changes, will have a major impact on food quantity and quality. The systems currently proposed have little resilience both in terms of contributing to climate change and of being able to cope with the expected altered conditions. This

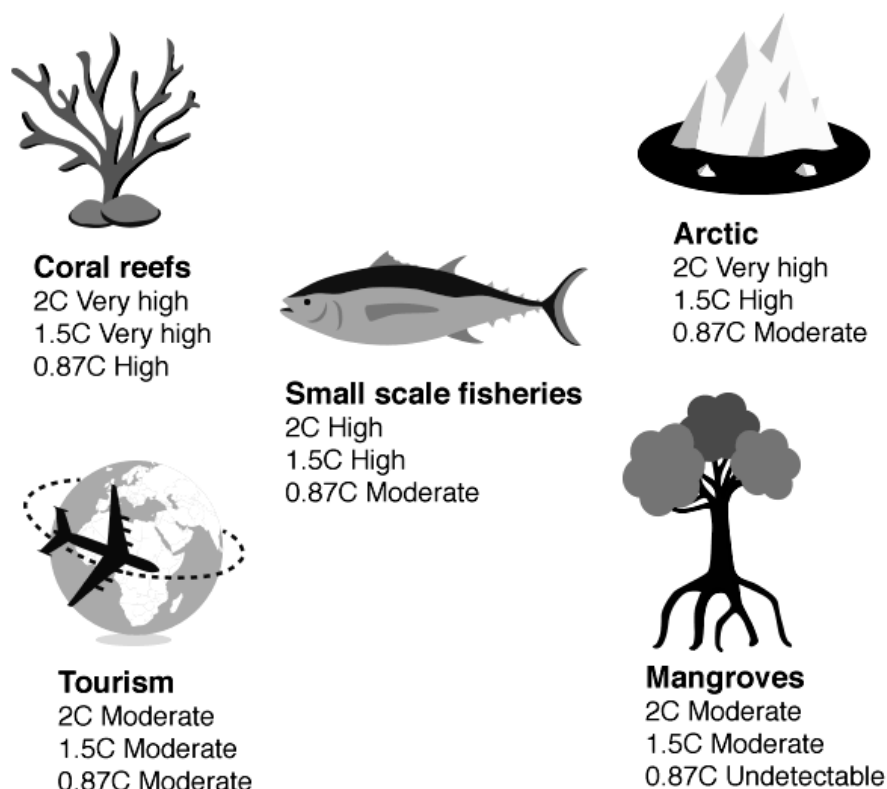
applies to most geographical areas given that the anticipated changes are spread across the globe, albeit with different levels of impact.

- Displacement

Continued population growth in locations at high risk of climate-related natural disasters means that more and more people are likely to be displaced by extreme environmental events over the coming years. In November 2013, more than 4 million people were displaced in the Philippines alone by Typhoon Haiyan.

Risks for natural, managed and human systems

Impact of average global temperature above pre-industrial level



Source:IPCC

BBC

Figure 10

3.1.5 Future Projections

Global climate is projected to change continuously over this century and beyond. The magnitude of climate change beyond the next few decades depends primarily on the amount of heat-trapping gases emitted globally, and how sensitive the Earth's climate is to those emissions. By 2020, models project that global surface temperature will be more than 0.5°C (0.9°F) warmer than the 1986-2005 average, regardless of which carbon dioxide emissions pathway the world follows. The length of the frost-free season (and the corresponding growing season) will also increase.

The recent trend towards increased heavy precipitation events will continue. Sea levels are expected to rise between 10 and 32 inches (26 and 82 centimetres) or higher by the end of the century. Hurricanes and other storms like Fani are likely to become stronger. Floods and droughts will become more common. Less freshwater will be available, since glaciers store about three-quarters of the world's freshwater. Some diseases will spread, such as mosquito-borne malaria (and the 2016 resurgence of the Zika virus). Ecosystems will continue to change: Some species will move farther north or become more successful; others, such as polar bears, would not be able to adapt and could become extinct.

3.2 Acid Rain

What is acid rain?

Acid rain describes any form of precipitation that contains high levels of nitric and sulphuric acids. It can also occur in the form of snow, fog, and tiny bits of dry material that settle to the Earth. Normal rain is slightly acidic, with a pH of 5.6, while acid rain generally has a pH between 4.2 and 4.4.

Causes of Acid Rain

Rotting vegetation and erupting volcanoes release some chemicals that can cause acid rain, but most acid rain is a product of human activities. The biggest sources are coal-burning power plants, factories, and automobiles.

When humans burn fossil fuels, Sulphur Dioxide (SO_2) and Nitrogen Oxides (NO_x) are released into the atmosphere. Those air pollutants react with water, oxygen, and other substances to form airborne sulphuric and nitric acid. Winds may spread these acidic compounds through the atmosphere and over hundreds of miles. When acid rain reaches Earth, it flows across the surface in runoff water, enters water systems, and sinks into the soil.

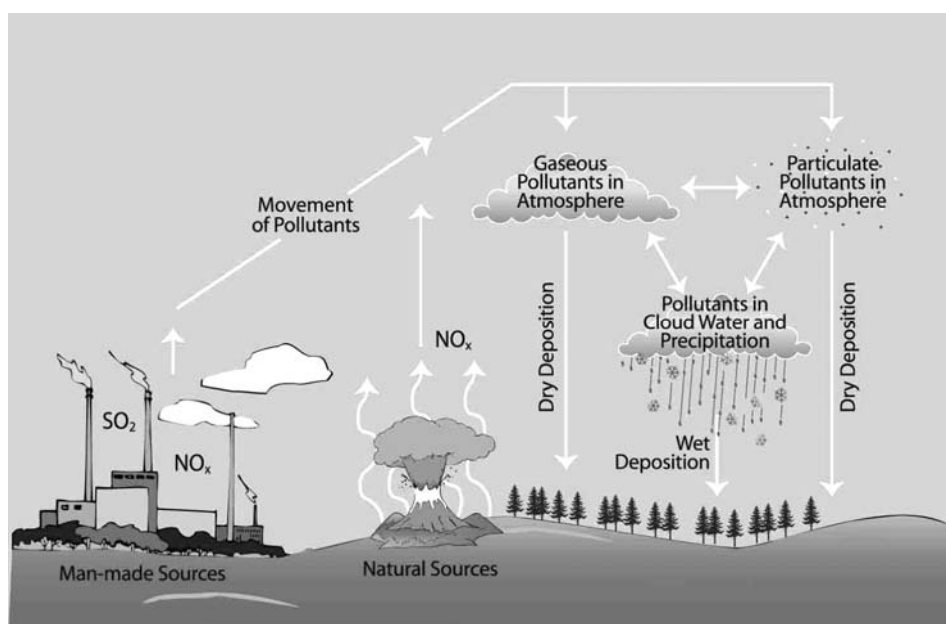


Figure 11 : Acid Rain

Effects of Acid Rain

Sulphur dioxide and nitrogen oxides are not primary greenhouse gases that contribute to global warming, one of the main effects of climate change; in fact, sulphur dioxide has a cooling effect on the atmosphere. But nitrogen oxides contribute to the formation of ground-level ozone, a major pollutant that can be harmful to people. Both gases cause environmental and health concerns because they can spread easily via air pollution and acid rain.

Acid rain has many ecological effects, especially on lakes, streams, wetlands, and other aquatic environments. Acid rain makes such waters more acidic, which results in more aluminium absorption from soil, which is carried into lakes and streams. That combination makes waters toxic to crayfish, clams, fish, and other aquatic animals.

Some species can tolerate acidic waters better than others. However, in an interconnected ecosystem, what affects some species eventually affects many more throughout the food chain, including non-aquatic species such as birds.

Acid rain and fog also damage forests, especially those at higher elevations. The acid deposits rob the soil of essential nutrients such as calcium and cause aluminium to be released in the soil, which makes it hard for trees to take up water. Trees' leaves and needles are also harmed by acids.

The effects of acid rain, combined with other environmental stressors, leave trees and plants less healthy, more vulnerable to cold temperatures, insects, and disease. The pollutants may also inhibit trees' ability to reproduce. Some soils are better able to neutralize acids than others. But in areas where the soil's "buffering capacity" is low, such as parts of the U.S. Northeast, the harmful effects of acid rain are much greater.

Acid deposits damage physical structures such as limestone buildings and cars. And when it takes the form of inhalable fog, acid precipitation can cause health problems including eye irritation and asthma.



Plates 4 : Effects of Acid Rain on Aquatic Ecosystem and on Leaves

Geographic Distribution of Acid Rain

Acidity in rain is measured by collecting samples of rain and measuring its pH. To find the distribution of rain acidity, weather conditions are monitored and rain samples are collected at sites all over the country. The areas of greatest acidity (lowest pH values) are located in the North-eastern United States. This pattern of high acidity is caused by the large number of cities, the dense population, and the concentration of power and industrial plants in the Northeast. New York, Pennsylvania, Virginia, Maryland, New Hampshire etc. Are the most affected provinces of USA. In addition, the prevailing wind direction brings storms and pollution to the Northeast from the Midwest, and dust from the soil and rocks in the North-eastern United States is less likely to neutralize acidity in the rain. The problem of acid rain is also experienced in North-Western Europe, particularly in United Kingdom, Germany, Denmark, Poland etc. Where there is rapid rate of industrialisation and urbanisation.

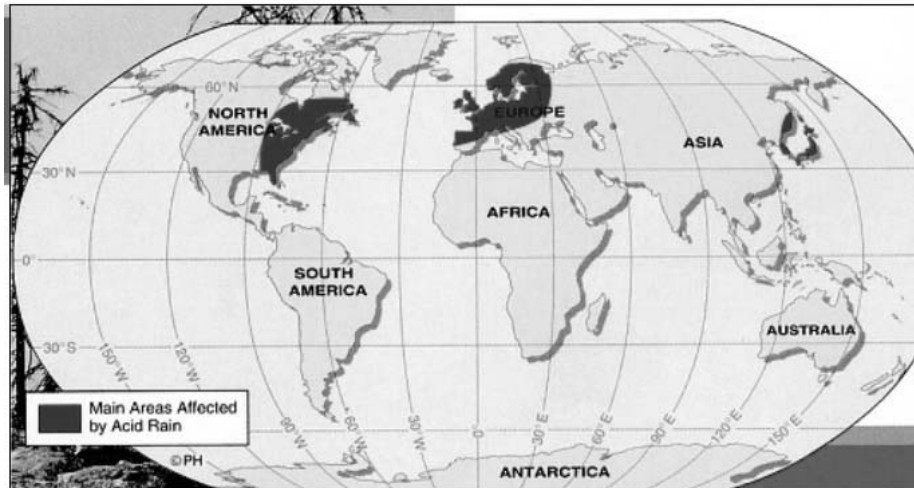


Figure 12 : Geographical Distribution of Acid Rain

Acid Rain and Rocks

When you hear or read in the media about the effects of acid rain, you are usually told about the lakes, fish, and trees. However, we are becoming aware of an additional concern: many of our historic buildings and monuments are located in the areas of highest acidity. In Europe, where buildings are much older and pollution levels have been ten times greater than in the United States, there is a growing awareness that pollution and acid rain are accelerating the deterioration of buildings and monuments.

Stone weathers (deteriorates) as part of the normal geologic cycle through natural chemical, physical, and biological processes when it is exposed to the environment. This weathering process, over hundreds of millions of years, turned the Appalachian Mountains from towering peaks as high as the Rockies to the rounded knobs we see today. Our concern is that air pollution, particularly in urban areas, may be accelerating the normal, natural rate of stone deterioration, so that we may prematurely lose buildings and sculptures of historic or cultural value.



Plate 5 : The Effects of Acid Rain on Stone Curvatures

What about Buildings?

Many buildings and monuments are made of stone, and many buildings use stone for decorative trim. Granite is now the most widely used stone for buildings, monuments, and bridges. Limestone is the second most used building stone. It was widely used before Portland cement became available in the early 19th century because of its uniform colour and texture and because it could be easily carved. Sandstone from local sources was commonly used in the North-eastern United States, especially before 1900. Nationwide, marble is used much less often than the other stone types, but it has been used for many buildings and monuments of historical significance. Because of their composition, some stones are more likely to be damaged by acidic deposition than others.

Granite is primarily composed of silicate minerals, like feldspar and quartz, which are resistant to acid attack. Sandstone is also primarily composed of silica and is thus resistant. A few sandstones are less resistant because they contain carbonate cement that dissolves readily in weak acid. Limestone and marble are primarily composed of the mineral calcite (calcium carbonate), which dissolves readily in weak acid; in fact, this characteristic is often used to identify the mineral calcite.

How Does Acid Precipitation Affect Marble and Limestone Buildings?

Acid precipitation affects stone primarily in two ways: dissolution and alteration. When sulphurous, sulphuric, and nitric acids in polluted air react with the calcite in marble and limestone, the calcite dissolves. In exposed areas of buildings and statues, we see roughened surfaces, removal of material, and loss of carved details. Stone surface material may be lost all over or only in spots that are more reactive.

You might expect that sheltered areas of stone buildings and monuments would not be affected by acid precipitation. However, sheltered areas on limestone and marble buildings and monuments show blackened crusts that have spalled (peeled) off in some places, revealing crumbling stone beneath. This black crust is primarily composed of gypsum, a mineral that forms from the reaction between calcite, water, and sulphuric acid. Gypsum is soluble in water; although it can form anywhere on carbonate stone surfaces that are exposed to sulphur dioxide gas (SO₂), it is usually washed away. It remains only on protected surfaces that are not directly washed by the rain. Gypsum is white, but the crystals form networks that trap particles of dirt and pollutants, so the crust looks black. Eventually the black crusts blister and spall off, revealing crumbling stone.

Effects of Acid Rain on the Taj Mahal, India

Taj Mahal is situated in Agra. The air in this place contains serious levels of sulphur and nitrogen oxides. This is due to the large number of power plants and industries set up around this area. All these led to acid rain. Acid rain reacted with the marble (calcium carbonate) of Taj Mahal. This caused damage to this wonderful structure, which had attracted many people from different parts of the world.

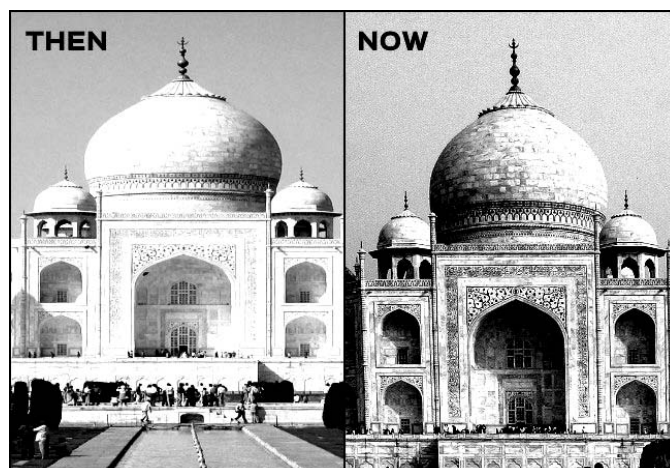


Plate 6 : Effect of Acid Rain on the Taj Mahal

Conclusion

Acid rain is a serious threat to the environment. To protect the Taj Mahal, the Government of India announced an action plan in 1995. The plan aims at clearing the air in 'Taj Trapezium'. Taj Trapezium refers to an area that includes towns of Agra, Mathura, Bharatpur and Firozabad. As a result of this plan, over 2000 industries situated inside the trapezium had switched over to the use of liquefied petroleum gas or natural gas in the place of coal or oil. It is the duty of each and every citizen of India to protect the historic monument, the Taj Mahal, India's pride.

3.3 Ozone Hole Depletion

The ozone layer is mainly found in the lower portion of the stratosphere, about 20 to 30 km (12 to 19 miles) above the earth, though the thickness varies seasonally and geographically. The ozone layer protects living things from harmful ultraviolet rays from the sun; without the protection of the ozone layer, millions of people would develop skin cancer and weakened immune systems.

3.3.1 The importance of ozone

From an environmental standpoint, ozone is a confusing molecule. In the troposphere, the region of the atmosphere from Earth's surface up to about 6 miles, ozone is a pollutant that is a component of photochemical smog. But in the stratosphere, the region of the atmosphere from 6 to 31 miles, ozone absorbs potentially damaging ultraviolet (UV) radiation.

As the Royal Swedish Academy of Sciences put it in its announcement of the 1995 Nobel Prize in Chemistry: "Even though ozone occurs in such small quantities, it plays an exceptionally fundamental part in life on earth. This is because ozone, together with ordinary molecular oxygen (O_2), is able to absorb the major part of the sun's ultraviolet radiation and therefore prevent this dangerous radiation from reaching the surface. Without a protective ozone layer in the atmosphere, animals and plants could not exist, at least not upon land."

Rowland's interest in the fate of CFCs in the atmosphere was sparked by a talk he heard at a conference in 1972. The speaker discussed results obtained by James Lovelock (*1919), a British scientist who had invented a highly sensitive way to measure trace gases. Lovelock had measured

trichlorofluoromethane (CFC-11) in the atmosphere in amounts that suggested that practically all of the CFC-11 ever manufactured was still present in the atmosphere.

Rowland decided to devote a portion of his research to understanding the fate of CFCs in the atmosphere. Although CFCs are inert in the lower troposphere, Rowland realized that they can be broken down by UV radiation once they drift up into the stratosphere. In late 1973, Rowland and Molina, who had recently joined Rowland's lab, used data from a variety of published sources to calculate that CFC molecules released near the surface of Earth would, over decades, wind up in the stratosphere where UV radiation would split off chlorine atoms. Each chlorine atom would react immediately with an ozone molecule, setting off a chain reaction that would destroy thousands of ozone molecules. In their paper, they estimated that if CFC use was banned immediately, ozone loss would go on for years. If CFC production continued, however, ozone loss would be even greater.

"When we realized there was a very effective chain reaction, that changed the CFC investigation from an interesting scientific problem to one that had major environmental consequences," Rowland told *Chemical & Engineering News* in an extensive interview in 2007. "You don't often get many chills down your back when you look at scientific results," he added, but that had been one of those moments.

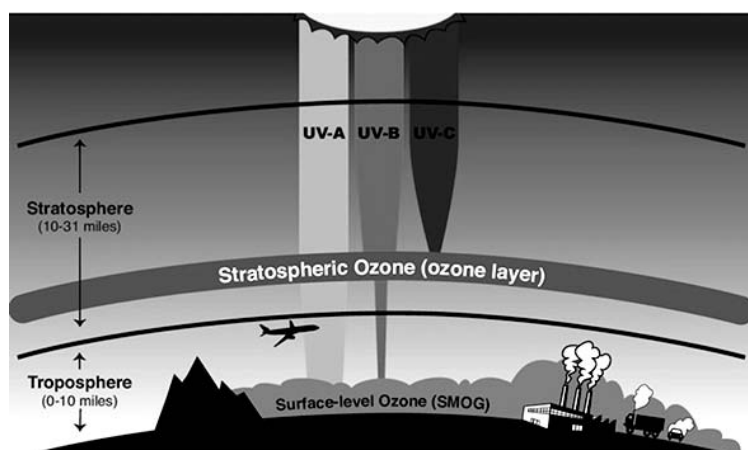


Figure 13 : Importance of Ozone Layer

3.3.2 Widespread use of CFCs

In the 1920s, refrigeration and air conditioning systems used compounds such as ammonia, chloromethane, propane and sulfur dioxide as refrigerants. Though effective, the compounds were toxic and flammable, and exposure to them could result in serious injury or death. A team of chemists at Frigidaire led by Thomas Midgely Jr. (1889-1944) worked to develop nontoxic, nonflammable alternatives to the refrigerants.

The team focused their effort on compounds containing carbon and halogens such as fluorine and chlorine. Such compounds were known to be volatile and chemically inert, both important properties for the team studying their use in refrigeration. The first compound they developed was dichlorodifluoromethane, CCl_2F_2 , which they dubbed "Freon." Midgely would receive the Society of Chemical Industry's Perkin Medal for this research in 1937; in 1941, he was awarded the Priestley Medal, the American Chemical Society's highest award, for his contributions to chemistry.

By the early 1970s, CFCs were in widespread use, and worldwide production of the compounds had reached nearly one million tons per year, representing roughly a \$500 million slice of the chemical industry.

Chlorofluoromethanes are being added to the environment in steadily increasing amounts. These compounds are chemically inert and may remain in the atmosphere for 40-150 years, and concentrations can be expected to reach 10 to 30 times present levels. Photodissociation of the chlorofluoromethanes in the stratosphere produces significant amounts of chlorine atoms, and leads to the destruction of atmospheric ozone.”

—F. Sherwood Rowland and Mario J. Molina, *Nature*, 1974

3.3.3 From Research to Resistance

In 1976, the National Academies of Science issued a report affirming the destructive effects of CFCs on stratospheric ozone. Congressional hearings reached similar conclusions, and states and the federal government began exploring bans on the use of CFCs in aerosol cans. The chemical industry maintained that the data on CFCs and stratospheric ozone were inconclusive and didn’t warrant drastic action. When Rowland lectured on CFCs, industry groups often released statements disputing his claims. As Molina recalls today, “Sherry [Rowland] was an established and respected scientist who regularly gave talks all over the world. It seemed that, because of his focus on CFCs and ozone depletion, he started getting fewer invitations to speak. That bothered him.”

Rowland and Molina and the other scientists trying to understand stratospheric chemistry faced serious and fundamental challenges. A significant number of chemical species were clearly involved in the interaction of CFCs and ozone in the stratosphere. Most are highly reactive and present in only trace amounts. Their chemistry was difficult to replicate in the laboratory.

Additionally, stratospheric ozone concentrations fluctuate naturally by geography and by season. The stratosphere is not an easy place to do research in. Measurements of ozone concentration were carried out by instruments carried into the stratosphere by balloons and aircraft. Ozone was also measured by instruments on satellites orbiting Earth, though satellite technology in the mid-1970s was still rather primitive.

All of these uncertainties gave critics of Rowland and Molina’s hypothesis a lot of material to work with. They argued, to many very convincingly, that it simply didn’t make sense to take action against a class of highly useful chemicals on the basis of such flimsy evidence. Industry critics, in particular, argued that it was one thing to propose phasing out the use of CFCs as propellants in aerosol cans—a relatively trivial use of the compounds—but quite another to consider banning their use in refrigerators and air conditioners, where obvious alternatives to CFCs simply didn’t exist at that time.

3.3.4 Antarctic ozone hole

The crucial evidence supporting the CFC hypothesis came from British scientists working at the Halley Bay Station of the British Antarctic Survey, who had been taking ground-based measurements of total ozone for decades. In 1984, Joseph C. Farman (1930-2013) and his colleagues at BAS studied the raw data and found that stratospheric ozone had decreased greatly since the 1960s. In 1985, the

scientists published an article in Nature announcing that stratospheric ozone over Antarctica was reduced 40% in September, the end of the austral winter.

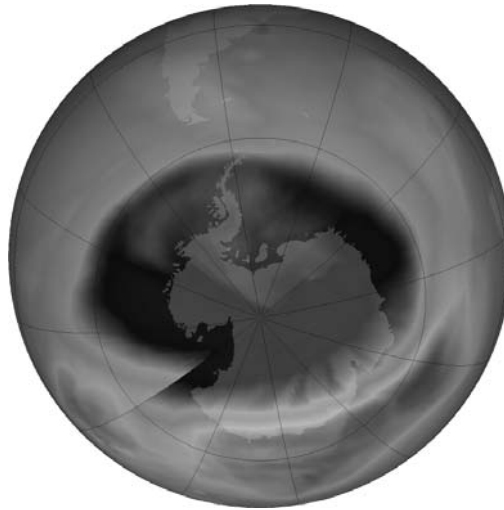


Figure 14 : Antarctica Ozone Hole

The Antarctic ozone hole, as it came to be known, made depletion of the ozone layer a real and present danger to lawmakers and the public at large. Predictions of significant increases in the incidence of skin cancer resulting from continued use of CFCs spurred international action. In 1987, 56 countries agreed under what became known as the Montreal Protocol to cut CFC production and use in half. In subsequent years, the protocol was strengthened to require an eventual worldwide phase out of the production of CFCs and other ozone depleting chemicals.

As a result of Rowland and Molina's work, humans for the first time realized that their activities could affect Earth's environment on a planetary scale. As Molina says today, "It doesn't matter where CFCs are emitted. It is a global problem. What is important is that it led to an international agreement that solved the problem." The saga of CFCs and the ozone layer holds many lessons for humanity dealing with the even larger challenge of global climate change.

4.1 Concept of Ecological Footprint

The ecological footprint measures human demand on nature, i.e., the quantity of nature it takes to support people or an economy. It tracks this demand through an ecological accounting system. The accounts contrast the biologically productive area people use for their consumption to the biologically productive area available within a region or the world (bio capacity - the productive area that can regenerate what people demand from nature). In short, it is a measure of human impact on Earth's ecosystem and reveals the dependence of the human economy on natural capital.

The ecological footprint is defined as the biologically productive area needed to provide for everything people use: fruits and vegetables, fish, wood, fibres, absorption of carbon dioxide from fossil fuel use, and space for buildings and roads.

Ecological footprint analysis is widely used around the Earth in support of sustainability assessments. It can be used to measure and manage the use of resources throughout the economy and

explore the sustainability of individual lifestyles, goods and services, organizations, industry sectors, neighbourhoods, cities, regions and nations.

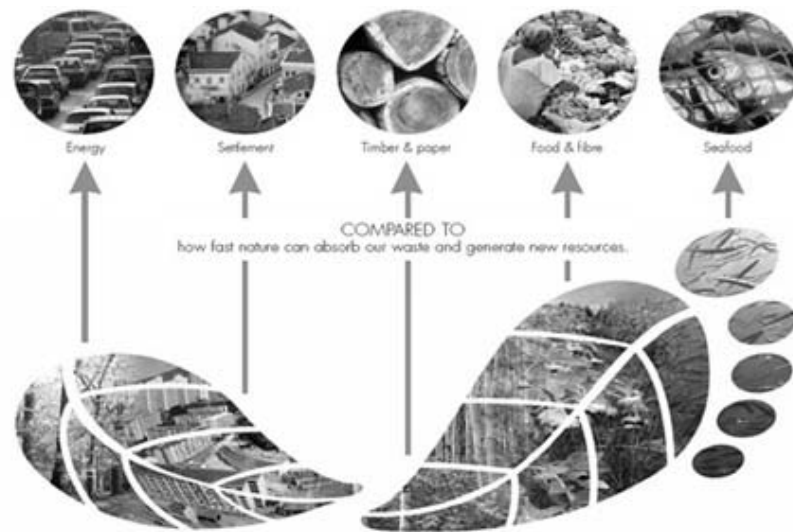


Figure 15 : Ecological Footprint

Source: Accessed from theretailinteligence.com

4.1.1 Overview

The first academic publication about the ecological footprint was by William Rees in 1992. The ecological footprint concept and calculation method was developed as the PhD dissertation of Mathis Wackernagel, under Rees' supervision at the University of British Columbia in Vancouver, Canada, from 1990–1994. Originally, Wackernagel and Rees called the concept "appropriated carrying capacity". To make the idea more accessible, Rees came up with the term "ecological footprint," inspired by a computer technician who praised his new computer's "small footprint on the desk." In early 1996, Wackernagel and Rees published the book *Our Ecological Footprint: Reducing Human Impact on the Earth*.

Ecological footprint analysis compares human demand on nature with the biosphere's ability to regenerate resources and provide services. It does this by assessing the biologically productive land and marine area required to produce the resources a population consumes and absorb the corresponding waste, using prevailing technology. Footprint values at the end of a survey are categorized for Carbon, Food, Housing, and Goods and Services as well as the total footprint number of Earths needed to sustain the world's population at that level of consumption. This approach can also be applied to an activity such as the manufacturing of a product or driving of a car. This resource accounting is similar to life cycle analysis wherein the consumption of energy, biomass (food, fiber), building material, water and other resources are converted into a normalized measure of land area called 'global hectares' (gha).

Per capita ecological footprint (EF) is a means of comparing consumption and lifestyles, and checking this against nature's ability to provide for this consumption. The tool can inform policy by examining to what extent a nation uses more (or less) than is available within its territory, or to what extent the nation's lifestyle would be replicable worldwide. The footprint can also be a useful tool to

educate people about carrying capacity and over-consumption, with the aim of altering personal behavior. Ecological footprints may be used to argue that many current lifestyles are not sustainable. Such a global comparison also clearly shows the inequalities of resource use on this planet at the beginning of the twenty-first century.

In 2006, the average biologically productive area per person worldwide was approximately 1.8 global hectares (gha) per capita. The U.S. footprint per capita was 9.0 gha, and that of Switzerland was 5.6 gha per person, while China's was 1.8 gha per person. The WWF claims that the human footprint has exceeded the biocapacity (the available supply of natural resources) of the planet by 20%. Wackernagel and Rees originally estimated that the available biological capacity for the 6 billion people on Earth at that time was about 1.3 hectares per person, which is smaller than the 1.8 global hectares published for 2006, because the initial studies neither used global hectares nor included bioproductive marine areas.

Ecological footprint analysis is now widely used around the globe as an indicator of environmental sustainability. It can be used to measure and manage the use of resources throughout the economy. It can be used to explore the sustainability of individual lifestyles, goods and services, organizations, industry sectors, neighborhoods, cities, regions and nations. Since 2006, a first set of ecological footprint standards exist that detail both communication and calculation procedures. They are available at www.footprintstandards.org and were developed in a public process facilitated by Global Footprint Network and its partner organizations.

4.1.2 Implications

There are several advantages and limitations associated with the development of the ecological footprint concept. The major advantage of the ecological footprint concept over some other indicators like environmental space is that the former concept gives a clear, unambiguous message often in an easily digested form. The clarity of the message is an important function of any indicator for both policy makers and the general public. Next, the calculation upon which the ecological footprint is based is relatively easy to undertake and much of the data is available at different spatial scales. Third, more detailed calculations do include trade within the ecological footprint. If world trade were included then, under the assumption of all areas maintaining their inhabitants' standards of living, there would be some losers as well as winners. A glance at the Human Development Index gives some empirical support of the increasing numbers of poor within the Third World as well as pockets of poor and a growing underclass in rich Western democracies. Fourth, the measure is simply stated as a stock, for example, x units of land per capita. It is obvious that each areal unit can also supply a flow of goods, information, natural and manmade capital as well as pollution into and out of the region.

4.2 Concept of Sustainable Development

Sustainable development is the organizing principle to meet human development goals while at the same time sustaining the ability of natural systems to provide the natural resources and ecosystem services upon which the economy and society depend. The desired result is a state of society where living conditions and resource use continue to meet human needs without undermining the integrity and stability of the natural system. Sustainable development can be classified as development that meets the needs of the present without compromising the ability of future generations. In 1987, the United Nations World Commission on Environment and Development released the report *Our Common Future*, commonly called the Brundtland Report. The report included what is now one of the most widely recognised definitions of sustainable development. 'Sustainable development is

development that meets the needs of the present without compromising the ability of future generations to meet their own needs.’

The result of a UN-convened commission created to propose “a global agenda for change” in the concept and practices of development, the Brundtland report signalled the urgency of re-thinking our ways of living and governing. To “responsibly meet humanity’s goals and aspirations” would require new ways of considering old problems as well as international co-operation and co-ordination. The World Commission on Environment and Development, as it was formally called, sought to draw the world’s attention to “the accelerating deterioration of the human environment and natural resources and the consequences of that deterioration for economic and social development.” In establishing the commission, the UN General Assembly explicitly called attention to two important ideas:

- o The well-being of the environment, of economies and of people is inextricably linked.
- o Sustainable development involves co-operation on a global scale.

Sustainable development is about integration: developing in a way that benefits the widest possible range of sectors, across borders and even between generations. In other words, our decisions should take into consideration potential impact on society, the environment and the economy, while keeping in mind that: our actions will have impacts elsewhere and our actions will have an impact on the future.

We tend to arrange things compartmentally, by divisions and departments, governments and communities; even households are rarely set up as holistic systems. Ministries of agriculture, finance, the interior and foreign affairs handle the issues that come under their domain. We divide up the tasks of our daily lives: work, rest, errands and holidays. It is not that we can’t see business, government or home life as a “whole” – making a household budget or a corporate strategy are examples of just this type of exercise – but in the bustle of our complex lives it can be difficult to take the time to see beyond the most immediate or obvious concerns. Often, as the old saying goes, we can’t see the forest for the trees. The concept of sustainable development has been used to articulate several essential shifts of perspective in how we relate to the world around us and, consequently, how we expect governments to make policies that support that world view.

“Governments face the complex challenge of finding the right balance between the competing demands on natural and social resources, without sacrificing economic progress.”

Sustainable Development: Critical Issues

First, there is the realisation that economic growth alone is not enough: the economic, social and environmental aspects of any action are interconnected. Considering only one of these at a time leads to errors in judgment and “unsustainable” outcomes. Focusing only on profit margins, for example, has historically led to social and environmental damages that cost society in the long run. By the same token, taking care of the environment and providing the services that people need depends at least in part on economic resources.

Next, the interconnected, or interdependent, nature of sustainable development also calls for going beyond borders – whether they are geographical or institutional – in order to co-ordinate strategies and make good decisions. Problems are rarely easily contained within predefined jurisdictions such as one government agency or a single neighbourhood, and intelligent solutions require cooperation as part of the decision-making process.



Figure 16 : Sustainable Development

4.2.1 The Three Pillars of Sustainable Development

At the core of sustainable development is the need to consider “three pillars” together: society, the economy and the environment. No matter the context, the basic idea remains the same – people, habitats and economic systems are interrelated. We may be able to ignore that interdependence for a few years or decades, but history has shown that before long we are reminded of it by some type of alarm or crisis. The fact of the matter is that we depend on ecosystems and the services they provide in order to do what we do: run businesses, build communities, feed our populations and much more. Whether we consider the more obvious, immediately vital examples – the need for soil that can grow food or for clean water to drink – or the less obvious but equally significant things like oxygen production during photosynthesis or waste processing by bacterial decomposers, we cannot avoid the conclusion that we depend on the environment for our existence. If we damage or destroy the capacity of the environment to provide these services we may face consequences for which we are completely unprepared.

“As a group, women – and their potential contributions to economic advances, social progress and environmental protection – have been marginalised.”

Gender and Sustainable Development

In the same way, the long-term stability and success of societies rely on a healthy and productive population. A society (or communities within a larger society) that faces unrest, poverty and disease will not develop in the long term: social well-being and economic well-being feed off each other, and the whole game depends on a healthy biosphere in which to exist.

Understanding the complex connections and interdependence of the three pillars requires some effort, and the effort has to be constant. Whether we’re talking about the duration of political

cycles or the length of time the media focuses on a particular issue, the question of our collective attention span is an important one for sustainable development.

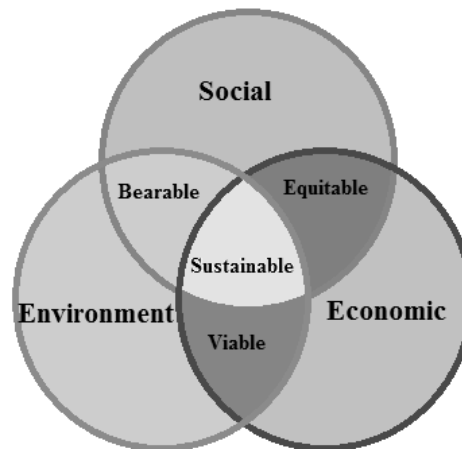


Figure 17 : Sustainable Development

4.2.2 Sustainable Development Goals

“The 2030 Agenda and its 17 Sustainable Development Goals (SDGs), adopted in 2015, provide a coherent, holistic framework for addressing these challenges and their interconnections. (...) They require member states to address the social, economic and environmental dimensions of sustainable development in a balanced manner. Their implementation must embody the principles of inclusiveness, integration and ‘leaving no one behind’.”

– António Guterres, United Nations Secretary-General

The Sustainable Development Goals (SDGs), otherwise known as the Global Goals, are a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity. These 17 Goals build on the successes of the Millennium Development Goals, while including new areas such as climate change, economic inequality, innovation, sustainable consumption, peace and justice, among other priorities. The goals are interconnected – often the key to success on one will involve tackling issues more commonly associated with another.

Goal 1: No poverty

Goal 2: Zero hunger

Goal 3: Good health and Wellbeing

Goal 4: Quality Education

Goal 5: Gender equality

Goal 6: Clean water and sanitation

Goal 7: Affordable and clean energy

Goal 8: Decent work and economic growth

Goal 9: Industry, innovation and infrastructure

Goal 10: Reduced inequalities

Goal 11: Sustainable cities and communities

Goal 12: Responsible consumption and production

Goal 13: Climate action

Goal 14: Life below water

Goal 15: Life on land

Goal 16: Peace, justice and strong institutions

Goal 17: Partnerships for the goals



This comprehensive agenda recognises that it is no longer sufficient just to focus on economic growth, but on fairer and more equal societies, and a safer and more prosperous planet. It recognises that the tasks of peace, justice, environmental protection, and industrial development are not disconnected from each other, but part of the same change. It recognises, above all, that global and interconnected challenges can only be fought with global and interconnected solutions. It is an ambitious plan that will require a renewed global partnership between governments, businesses, the civil society, and individuals. As we make progress towards achieving the 169 targets, we will reorient national and global development on a more sustainable, more resilient path.

National Action on the SDGs in India

NITI Aayog, the Government of India's premier think tank, has been entrusted with the task of coordinating the SDGs. NITI Aayog has undertaken a mapping of schemes as they relate to the SDGs and their targets, and has identified lead and supporting ministries for each target. They have adopted a government-wide approach to sustainable development, emphasising the interconnected nature of

the SDGs across economic, social and environmental pillars. States have been advised to undertake a similar mapping of their schemes, including centrally sponsored schemes.

In addition, the Ministry of Statistics and Programme Implementation (MoSPI) has been leading discussions for developing national indicators for the SDGs. State governments are key to India's progress on the SDG Agenda and several of them have already initiated action on implementing the SDGs.

Just as our vision behind Agenda 2030 is lofty, our goals are comprehensive. It gives priority to the problems that have endured through the past decades. And, it reflects our evolving understanding of the social, economic and environmental linkages that define our lives... The sustainable development of one-sixth of humanity will be of great consequence to the world and our beautiful planet.

– Narendra Modi, Prime Minister of India

The Government of India is strongly committed to the 2030 Agenda, including the SDGs, as evidenced by the statements of the Prime Minister and other senior Ministers at national and international meetings. India's national development goals and its “*sab ka saath, sab ka vikas*” or “development with all, and for all,” policy initiatives for inclusive development converge well with the SDGs, and India will play a leading role in determining the success of the SDGs, globally. As Prime Minister Narendra Modi noted, “These goals reflect our evolving understanding of the social, economic and environmental linkages that define our lives.”

Leave No One Behind

At the core of this global agenda for 2030 is the principle of universality: ‘Leave No One Behind’. It is critical to the implementation of these targets that they should be relevant to all governments and actors. Development in all its dimensions must be inclusive of all people, everywhere, and should be built through the participation of everyone, especially the most vulnerable and marginalized.

5.1 Role of IUCN

Founded in 1948, the International Union for Conservation of Nature (IUCN) is the world's oldest and largest global environmental organisation. With more than 1,200 Government and NGO members and almost 11,000 volunteer experts spread over 160 countries, the organisation forms an unmatched global reservoir of knowledge, action, influence and empowerment that has enabled IUCN to become the leading authority on environment and sustainable development.

Recognizing the organisation's commitment and expertise, IUCN was made a permanent observer at the United Nations (UN) Headquarters in 1999, making IUCN the only international organisation in the UN General Assembly with expertise on environmental issues. With growing global environmental concerns, the role of IUCN is now more critical than ever. India has a proud history of according high priority to environmental and conservation concerns, and has been one of the leaders on world stage on these issues. Naturally, India's association with IUCN goes back a long time -India became a State Member of IUCN in 1969. Today, IUCN has 39 Member Organisations in India, the highest number in Asia, and over 435 individual experts across the six IUCN Commissions. These Commissions, which unite experts globally, continuously appraise the state of the world's

natural resources and provide expert scientific, legal and policy advice on issues of environment, conservation and sustainable development.

The establishment of the IUCN India National Committee (INC) - a first of its kind committee in the region - consisting of IUCN's Indian members and Chaired by the Secretary, Ministry of Environment, Forests and Climate Change (MoEF&CC), Government of India (GoI) marked the beginning of the close association between IUCN and GoI to coordinate on environmental issues. Since then, a Memorandum of Understanding (MoU) between IUCN and the GoI has accorded IUCN the status of an autonomous, international, non-profit organisation. The IUCN India Country Office was established in New Delhi in 2007. IUCN is also committed towards engaging with various State Governments and its MoU with the Gujarat government to work on local conservation challenges, is a step in this direction.

5.1.1 Approaches

- Valuing and conserving nature.
- Effective and equitable governance of natural resources.
- Developing nature-based solutions to environmental and developmental challenges both on the global and local level.

The International Union for Conservation of Nature (IUCN) is a membership Union uniquely composed of both government and civil society organisations. It provides public, private and non-governmental organisations with the knowledge and tools that enable human progress, economic development and nature conservation to take place together.

Marine and Coastal

Healthy coastal ecosystems are critical lifelines that not only sustain incredible levels of biodiversity in and around it, but are also the natural providers for numerous livelihoods in their vicinity and beyond. However, a steady increase in the demand for coastal and marine products and services over the years has resulted in unsustainable exploitation of these precious resources, thus undermining the capacity of these ecosystems itself. Recognising the aforementioned challenges, IUCN India through its flagship Mangroves for the Future (MFF) regional initiative is advising and supporting MoEF&CC in addressing the pressing need for protecting and sustainably investing in India's marine and coastal ecosystems.

Livelihood Security and Sustainability

- ✓ Experts and various stakeholder groups unanimously agree that coastal and marine ecosystems cannot be conserved in the long-run without addressing the two critical issues of securing livelihoods of communities' dependent on these ecosystems and at the same time ensuring that this is done in a sustainable manner. The following steps have been taken by IUCN India under its MFF programme:
- ✓ Providing supplementary livelihood options and associated skill development to mangrove dependent communities in coastal states, thus reducing the anthropogenic pressure on mangroves as well as increasing income levels at project sites.
- ✓ Development of climate-adaptive livelihoods for vulnerable communities in the Sundarbans Biosphere Reserve, West Bengal

- ✓ Establishment and capacity building of Disaster Management Committees and Disaster Response Teams in Odisha and West Bengal

Ecosystem Research and Restoration

Apart from livelihood security and sustainability, it is equally important to promote and support new scientific research for a better understanding of these complex ecosystems. IUCN India has implemented the following steps under its MFF programme:

- ✓ First of its kind programme in Gujarat, mentoring 20 private sector companies to establish guidelines for community-based mangrove restoration. The highlight of this programme was restoration of more than 200 hectares of mangroves through capacity-building of the TATA Group to steer community driven mangrove plantations.
- ✓ Establishment of Village Mangrove Councils (linked with local Panchayats) in Odisha to implement long-term sustainable use of restored mangroves through community stewardship.
- ✓ Development of a regional restoration protocol for degraded sea grass beds in the Gulf of Mannar.
- ✓ Identification and targeted management of mangrove genetic hotspots through research in mangrove community composition and distribution in Maharashtra and southern Gujarat.

Policy Interventions and Governance

Effective policy interventions and transparent and robust governance are the pre-requisites for efficient actualization of the above-stated steps for conservation and restoration of coastal and marine ecosystems. IUCN-India has been relentlessly working on this crucial aspect by:

- ✓ Bringing together the scientific community and government bodies from across Asia to deliberate, discuss and establish sound ecosystem-based conservation approaches to marine fisheries, hence leading to focussed recommendations for regional interventions.
- ✓ Development of a concrete knowledge base on marine ecosystems and endangered dugongs and cetaceans in the Gulf of Mannar to facilitate effective trans-boundary ecosystem management.
- ✓ Development of scientifically informed and community-based ecosystem management plans for the Vembanad-Kol backwaters in Kerala and the sea grass ecosystem of Palk Bay in Tamil Nadu, at the behest of the State and Central Governments.

Education and Awareness

IUCN-India's MFF programme has taken the following steps to educate and raise awareness about coastal and marine ecosystems:

- ✓ Development of field-based curriculum on marine and coastal ecosystems for schools along the western and southern coasts of India.
- ✓ Development of education and knowledge products in partnership with MoEF&CC. These knowledge products that have been integrated as resource materials in schools and universities have now been disseminated across 10 countries in the Asia region.

- ✓ Building-up of a pool of national experts on mangrove restoration techniques and framing an Integrated Coastal Zone Management (ICZM) plan to support and streamline national marine and coastal conservation efforts.

Research and Multi-Stakeholder Dialogues

IUCN India has facilitated formation of Joint Research Teams (JRTs) consisting of experts and institutions from Bangladesh and India. Supported by multi-stakeholder dialogues, these JRTs are mandated to undertake research on providing trans-boundary perspectives for suitable policy framing. This includes the following:

- ✓ Identification of the causes of deterioration of waterways and establishment of recommendations resulting in policy-development towards strengthening inland navigation.
- ✓ Locating information gaps in the top-down dissemination of early flood warnings and in the communication of scientific information to local communities. A pilot project designed to address these gaps is underway in the Khagaria district of Bihar.
- ✓ Analysis of environmental flow assessment methodologies for the Sundarbans ecosystem. Based on this analysis, a pilot to fine-tune these methodologies is currently underway in the Hooghly, Ichhamati and Gorai rivers.

5.2 Role of UNDP

The United Nations Development Programme (UNDP) is the United Nations' global development network. Headquartered in New York City, UNDP advocates for change and connects countries to knowledge, experience and resources to help people build a better life. It provides expert advice, training and grants support to developing countries, with increasing emphasis on assistance to the least developed countries. It promotes technical and investment cooperation among nations.

Funding

The UNDP was founded on 22 November 1965 with the merging of the Expanded Programme of Technical Assistance (EPTA) and the Special Fund. The rationale was to "avoid duplication of [their] activities". The EPTA was set up in 1949 to help the economic and political aspects of underdeveloped countries while the Special Fund was to enlarge the scope of UN technical assistance. The Special Fund arose from the idea of a Special United Nations Fund for Economic Development (SUNFED) (which was initially called the United Nations Fund for Economic Development (UNFED)).



Countries such as the Nordic countries were proponents of such a United Nations (UN) controlled fund. However, the fund was opposed by developed countries, especially by the United States who was wary of the Third World dominating such a funding and preferred it to be under the auspices of the World Bank. The concept of SUNFED was dropped to form the Special Fund. This Special Fund was a compromise over the SUNFED concept, it did not provide investment capital, but only helped to bring pre-conditions for private investment.

With the US proposing and creating the International Development Association within the World Bank's umbrella, the EPTA and the Special Fund appeared to be conducting similar work. In

1962, the United Nations Economic and Social Council asked the Secretary General to consider the merits and disadvantages of merging UN technical assistance programs and in 1966, the EPTA and the Special Fund merged to form the UNDP.

Major focus on:

- Sustainable development
- Democratic governance and peace building
- Climate and disaster resilience

Six Signature Solutions

- Keeping people out of POVERTY
- GOVERNANCE for peaceful, just, and inclusive societies
- Crisis prevention and increased RESILIENCE
- ENVIRONMENT: Nature-based solutions for development
- Clean, affordable ENERGY
- Women's empowerment and GENDER equality

UNDP in India

UNDP works in almost 170 countries and territories, helping to achieve the eradication of poverty, and the reduction of inequalities and exclusion. It helps countries to develop policies, leadership skills, partnering abilities, institutional capabilities and build resilience in order to sustain development results.

UNDP has worked in India since 1951 in almost all areas of human development, from democratic governance to poverty eradication, to sustainable energy and environmental management. UNDP's programmes are aligned with national priorities and are reviewed and adjusted annually.

The United Nations provides strategic support to India to help the country achieve its aspirations to end poverty and inequality and to promote sustainable development in line with the globally agreed SDGs. The UN also supports India, as the world's largest democracy, in the country's ambitious commitments to rapid change and development priorities.

Locations in India

The UN head office is located in New Delhi. Additionally, they have a field presence in Andhra Pradesh, Arunachal Pradesh, Daman and Diu, Delhi, Gujarat, Haryana, Himachal Pradesh, Goa, Jammu & Kashmir, Karnataka, Kerala, Manipur, Meghalaya, Mizoram, Nagaland, Punjab and Chandigarh, Sikkim, Tamil Nadu, Tripura, Uttarakhand and West Bengal.

5.3 Role of UNEP



The United Nations Environment Programme (UNEP) is an agency of United Nations and coordinates its environmental activities, assisting developing countries in implementing environmentally sound policies and practices. It was founded by Maurice Strong, its first director, as a result of the United Nations Conference on the Human Environment (Stockholm Conference) in June 1972 and has overall responsibility for environmental problems among United Nations agencies but international talks on specialized issues, such as addressing climate change or combating desertification.

Six Areas of Concentration

UNEP re-organised its work programme into six strategic areas as part of its move to results based management. The selection of six areas of concentration was guided by scientific evidence, the UNEP mandate and priorities emerging from global and regional forums.

1. **CLIMATE CHANGE** UNEP strengthens the ability of countries to integrate climate change responses by providing leadership in adaptation, mitigation, technology and finance. UNEP is focusing on facilitating the transition to low-carbon societies, improving the understanding of climate science, facilitating the development of renewable energy and raising public awareness.

2. **POST-CONFLICT AND DISASTER MANAGEMENT** UNEP conducts environmental assessments in crisis-affected countries and provides guidance for implementing legislative and institutional frameworks for improved environmental management. Activities undertaken by UNEP's Post-Conflict & Disaster Management Branch (PCDMB) include post-conflict environmental assessment in Afghanistan, Côte d'Ivoire, Lebanon, Nigeria and Sudan.

3. **ECOSYSTEM MANAGEMENT** Facilitates management and restoration of ecosystems in a manner consistent with sustainable development, and promotes use of ecosystem services. Examples include the Global Programme of Action (GPA) for the Protection of the Marine Environment from Land-Based Activities.

4. **ENVIRONMENTAL GOVERNANCE** UNEP supports governments in establishing, implementing and strengthening the necessary processes, institutions, laws, policies and programs to achieve sustainable development at the country, regional and global levels, and mainstreaming environment in development planning.

5. **HARMFUL SUBSTANCES** UNEP strives to minimise the impact of harmful substances and hazardous waste on the environment and human beings. UNEP has launched negotiations for a global agreement on mercury, and implements projects on mercury and the Strategic Approach to International Chemicals Management (SAICM) to reduce risks to human health and the environment.

6. **RESOURCE EFFICIENCY/SUSTAINABLE CONSUMPTION AND PRODUCTION** UNEP focuses on regional and global efforts to ensure natural resources are produced, processed and consumed in a more environmentally friendly way. For example, the Marrakesh Process is a global strategy to support the elaboration of a 10-Year Framework of Programs on sustainable consumption and production.

5.4 Role of IPCC

The Intergovernmental Panel on Climate Change (IPCC) is the international body for assessing the science related to climate change. The IPCC was set up in 1988 by the World Meteorological

Organization (WMO) and United Nations Environment Programme (UNEP) to provide policymakers with regular assessments of the scientific basis of climate change, its impacts and future risks, and options for adaptation and mitigation.

The IPCC was established to provide the decision-makers and others interested in climate change with an objective source of information about climate change. The IPCC does not conduct any research nor does it monitor climate related data or parameters. Its role is to assess on a comprehensive, objective, open and transparent basis the latest scientific, technical and socio-economic literature produced worldwide relevant to the understanding of the risk of human-induced climate change, its observed and projected impacts and options for adaptation and mitigation. IPCC reports should be neutral with respect to policy, although they need to deal objectively with policy relevant scientific, technical and socio economic factors. They should be of high scientific and technical standards, and aim to reflect a range of views, expertise and wide geographical coverage.

The role of the IPCC is to assess on a comprehensive, objective, open and transparent basis the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation. IPCC reports should be neutral with respect to policy, although they may need to deal objectively with scientific, technical and socio-economic factors relevant to the application of particular policies.



Through its assessments, the IPCC determines the state of knowledge on climate change. It identifies where there is agreement in the scientific community on topics related to climate change, and where further research is needed. The reports are drafted and reviewed in several stages, thus guaranteeing objectivity and transparency. The IPCC does not conduct its own research.

IPCC reports are neutral, policy-relevant but not policy-prescriptive. The assessment reports are a key input into the international negotiations to tackle climate change. Created by the United Nations Environment Programme (UN Environment) and the World Meteorological Organization (WMO) in 1988, the IPCC has 195 Member countries.

Working Groups and Task Force

IPCC assessments and special reports are prepared by three Working Groups, each looking at a different aspect of the science related to climate change: Working Group I (The Physical Science Basis), Working Group II (Impacts, Adaptation and Vulnerability), and Working Group III (Mitigation of Climate Change). The IPCC also has a Task Force on National Greenhouse Gas Inventories, whose main objective is to develop and refine a methodology for the calculation and reporting of national greenhouse gas emissions and removals.

5.5 Role of UNFCCC

The ultimate objective of the United Nations Framework Convention on Climate Change is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.

6.1. Agro-Forestry

Agroforestry is a land use management system in which trees or shrubs are grown around or among crops or pastureland. This intentional combination of agriculture and forestry has varied benefits, including increased biodiversity and reduced erosion.



Plate 7 :
<https://www.geographyandyou.com/>

As world population increases, the need for more productive and sustainable use of the land becomes more urgent. According to the United Nations, more than seven billion people populated the Earth in 2011 and this number is expected to go up to 9.3 billion by the mid-century. To meet the demand for food by 2050, production will have to increase by over 60%. These figures, coupled with current problems borne out of past and existing non-sustainable land use practices, provide the case for changing the way we manage lands

and our production of agricultural and tree goods.

Thanks to its multifunctional properties, agroforestry is part of the solution to addressing these issues, whether they are environmental, economic or social. Agroforestry systems include both traditional and modern land-use systems where trees are managed together with crops and/or animal production systems in agricultural settings. They are dynamic, ecologically based, natural resource management systems that diversify and sustain production in order to increase social, economic and environmental benefits for land users at all scales. In short, agroforestry provides an array of environmental goods and services that support integrated management of farmland and rural spaces. Following are the major benefits of practising agro-forestry.

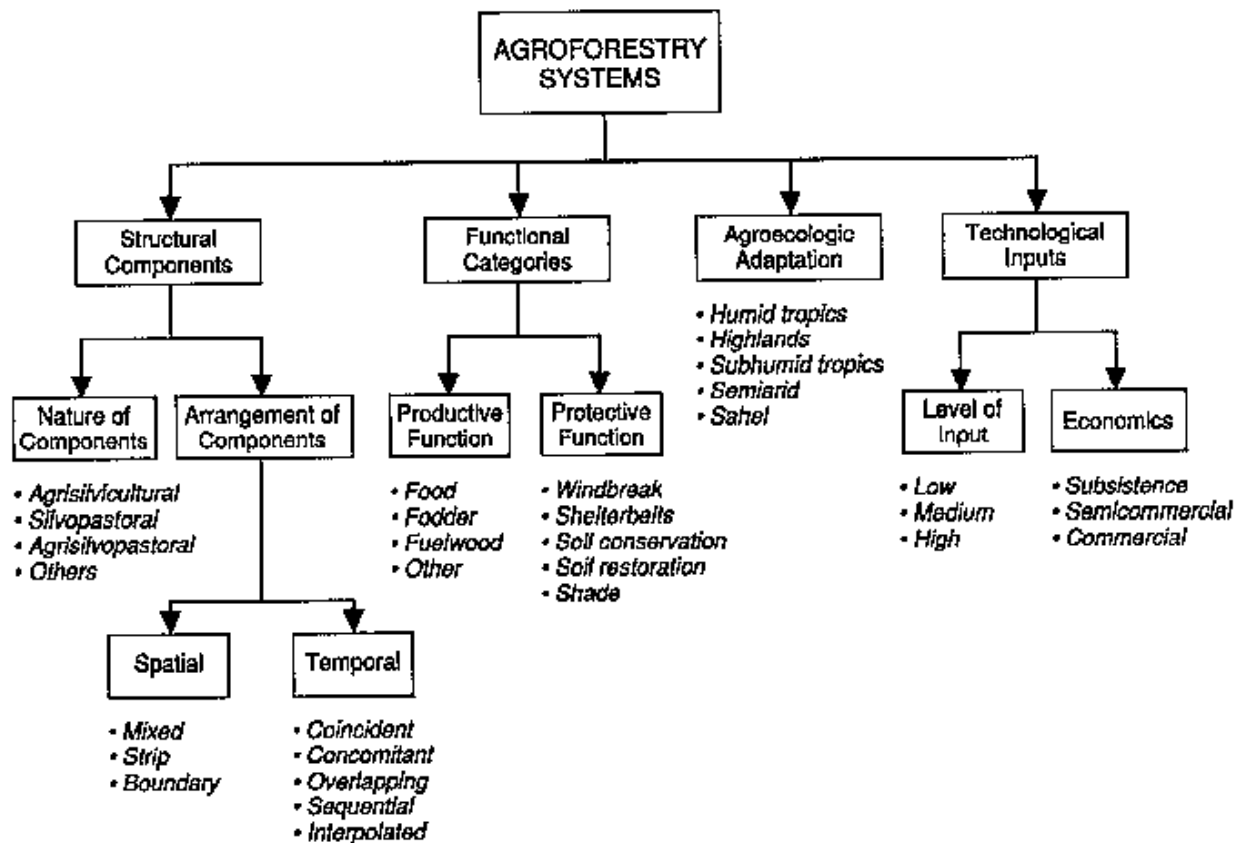


Figure 18 : Agroforestry Systems

6.1.1 Economic services

- Diversification of economic activities
- Diversification of agricultural revenues
- Increase in yield from conventional agricultural systems
- Reclamation of fragile or marginal lands

6.1.2 Environmental services

- Increase in plant and animal biodiversity
- Decrease in wind and water erosion
- Improvement in soil fertility
- Improvement in soil hydrology regimes
- Mitigation of air, sound and odour pollution
- Water treatment
- Carbon sequestration and storage
- Reduction in deforestation
- Improvement in microclimates
- Mitigation of climate change impacts on agriculture

6.1.3 Social services

- Job creation
- Food security
- Landscape enhancement
- Improvement in public opinion regarding agricultural and forestry activities

6.1.4 Cultural services

- Use of local and indigenous knowledge

6.1.5 Agro-forestry in Indian Subcontinent

Agroforestry has a long tradition in the Indian subcontinent. The socio-religious fabric of the people of the subcontinent is interwoven to a very great extent with rising, caring for and respecting trees. Trees are integrated extensively in the crop- and livestock-production systems of the region according to the agro-climatic and other local conditions.

While the multi-tier tree-crop combinations in the home gardens of the humid lowlands meet cash and household requirements, the *kherji* (*Prosopis cineraria*) and agricultural-crop combination in the hot arid region meets needs for fodder, small timber and food. The *Alnus nepalensis* and *Amomum subulatum* combination in the humid sub-temperate regions of Nepal and Bhutan and Sikkim State of India is an excellent example of a commercial but traditional agroforestry system. Deliberate growing of trees on field bunds, their sporadic distribution in agricultural fields, and the systematic retention of shade trees in tea and coffee plantations are other common examples of prevalent agroforestry practices. Similarly, it is a common practice to utilize the open interspaces in the newly planted orchards and forests for cultivating crops for 2-3 years and to interplant shade tolerant crops such as turmeric and ginger later.

In India alone it is estimated that the deficit of fuel-wood by the year 1990 will be of the order of 100 million m³ per year, and presently only a third of the fodder that is required to feed the country's livestock population is available. About 44 percent of the geographical area of India is subjected to serious erosion hazards, causing an estimated loss of 5,334 million tons of soil annually, 1,572 million tons of which find their way into the sea. In order to realize the goal of producing 225 million tons of food by the year AD 2000 in India, an estimated 20 million tons of plant nutrients would be required, a substantial part of which will have to be contributed by sources other than chemical fertilizers.

To cope with some of these challenges and tackle these problems of food and environmental security, the potentials of agroforestry need to be fully exploited. Presently some initiatives are being undertaken by the governments, farmers, non-government organizations and industries in the subcontinent to develop appropriate agroforestry systems and popularize them. Matchbox and paper industries have introduced cultivation of poplar trees in the areas about 30° N. Farmers have taken to planting *Eucalyptus*, *Casuarina* and *Acacia* trees either on field bunds or as block plantations. Cultivation of fruit trees has become popular in marginal lands in the arid regions. However, these efforts are only the beginning. Further sustained effort is required to develop agroforestry systems suitable for each agro-ecological region of the Indian subcontinent.



Plate 7 : Multi-tier Crop Cultivation

Agro-ecological characteristics of the Indian subcontinent

The monsoon, the seasonal reversal of winds and associated rains, develops most prominently over the Indian subcontinent and adjacent seas. The average annual rainfall of about 100 cm over the Indo-Gangetic plains is high for a region lying mostly in the subtropical high-pressure belt. Contrasts in climate are very striking: Cherrapunji, with the heaviest rainfall in the world, and the Thar Desert, with as little as 8 cm of rain per year, are almost on the same latitude (26° N). Almost every type of climate, from equatorial to alpine, is found in one part or the other of the subcontinent. The alpine climate occurs in the Himalayas within 400 km of the Tropic of Cancer. The northern plains experience higher summer temperatures than other land areas on the same latitude, and while over a large area relative humidity is over 80 percent during the south-west monsoon, the air is very dry at the height of summer in the north-west.

6.2 Social Forestry

Social forestry means the management and protection of forest and afforestation of barren and deforested lands with the purpose of helping environmental, social and rural development. The term, social forestry, was first used in 1976 by The National Commission on Agriculture, Government of India. It was then that India embarked upon the social forestry project with the aim of taking the pressure off currently existing forests by planting trees on all unused and fallow land.

The Indian government is trying to increase forest areas that are close to human settlement and have been degraded over the years due to human activities needed to be afforested. Trees were to be planted in and around agricultural fields. Plantation of trees along railway lines and roadsides, and river and canal banks were carried out. They were planted in village common land, government wasteland, and Panchayat land.



Plate 8 : Social Forestry
Source: <https://www.itcportal.com/>

Social forestry scheme was initiated in India to increase fuel availability in rural areas and to prevent soil erosion. This concept of village forests to meet the needs of the rural people is not new. It has existed through the centuries all over the country, but it is now being given a new character. This need for a social forestry scheme was felt as India has a dominant rural population that still depends largely on fuel wood and other biomass for their cooking and heating. This demand for fuel wood will not come down but the area under forest will reduce further due to the growing population and increasing human activities. Yet the government managed the projects for five years then gave them over to the village Panchayats (village council) to manage for themselves and generate products or revenue as they saw fit.

6.2.1 Objectives

- To fulfil the basic requirements such as fuel, fodder, small timber, supplementary food and income from surplus forest products to the rural area and replacement of cow-dung.
- To provide employment opportunities and to increase family income considerable for alleviating poverty.
- To develop cottage industries in rural areas.
- To organize them in their struggle for socioeconomic development and to integrate economic gains in the distribution of their benefits to the rural society.
- To provide congenial environment and preserve their cultural identity as their life related to forest.
- To indoctrinate the value of village level self-sufficiency and self-management in the production as well as distribution of forest products with social justice.
- To form the villagers into a well-knit community and an effective functional unit of society which can shape its own destiny.
- To play a vital role in the reclamation of degraded lands, conservation of soil and moisture, improvement of agricultural production and prevention of environmental deterioration.
- To increase the natural beauty of the landscape, create recreational forests for the benefit of rural and urban population.
- To protection of agricultural fields against wind speed and natural calamity.

- To solve the food problem of the rural area to a great extent. Certain edible fruits like cashew, mango, coconut and palms have high nutritional value and grow under social forestry programme.
- To utilize the available land according to its carrying capacity.



Plate 9 : Recreational Forest – A Benefit of Social Forestry

6.2.2 Types of Social Forestry

- **Farm Forestry**

Farm forestry is the name given to programmes which promote commercial tree growing by farmers on their own land. Farm forestry was defined by NCA (1976) as the practice of forestry in all its aspects in and the around the farms or village lands integrated with other farm operations.

- **Extension forestry**

Extension forestry is the practice of forestry in areas devoid of tree growth and other vegetation situated in places away from the conventional forest areas with the object of increasing the area under tree growth. It includes the following.

- **Mixed forestry**

Mixed forestry is the practice of forestry for raising fodder grass with scattered fodder trees, fruit trees and fuel wood trees on suitable wastelands, panchayat lands and village commons.

- **Linear Strip forestry**

These are the plantations of fast growing species along the bank of the river, canals, roads and the railways.

- **Shelterbelts**

Shelterbelt is defined as a belt of trees and or shrubs maintained for the purpose of shelter from wind, sun, snow drift, etc.

- **Rehabilitation of Degraded forests**

The degraded area under forests needs immediate attention for ecological restoration and for meeting the socio economic needs of the communities living in and around such areas.

- **Recreation forestry**

Recreation forestry is the practice of forestry with the object of raising flowering trees and shrubs mainly to serve as recreation forests for the urban and rural population. This type of forestry is also known as Aesthetic forestry.

6.2.3 Tree Species Commonly Used in Social Forestry

Acacia nilotica, Ailanthus excels, Albizzia procera, Albizzia lebbek, Anacardium occidentale, Artocarpus heterophyllus, Azadirachta indica, Bahinea speices, Casuarina equisetifolia, cocus nucifera, Dalbergia sissoo, Emblica officinalis, Eucalyptus spp., Gmelina arborea etc.

6.2.4 Achievements of Social Forestry

- ☐ Increased area under tree cover
- ☐ Increased production of industrial timbers, firewood and fodder
- ☐ Increased employment opportunities for the rural poor
- ☐ Improvement in environment
- ☐ Enhance the conservation of soil and water table.

6.3 Joint Forest Management

Joint Forest Management often abbreviated as JFM is the official and popular term in India for partnerships in forest movement involving both the state forest departments and local communities. The policies and objectives of Joint Forest Movement are detailed in the Indian comprehensive National Forest Policy of 1988 and the Joint Forest Management Guidelines of 1990 of the Government of India.

The Indian Forest Policy of 1988 (MoEF, 1988) and the subsequent government resolution on participatory forest management (MoEF, 1990) emphasize the need for people's participation in natural forest management. The policy document asserts that local communities should be motivated to identify themselves with the development and protection of the forests from which they derive benefits. Thus, the policy envisages a process of joint management of forests by the state governments (which have nominal responsibility) and the local people, which would share both the responsibility for managing the resource and the benefits that accrue from this management.

Under joint forest management (JFM), village communities are entrusted with the protection and management of nearby forests. The areas concerned are usually degraded or even deforested areas. However, in Andhra Pradesh and Madhya Pradesh all village fringe forests can come under JFM. The communities are required to organize forest protection committees, village forest committees, village forest conservation and development societies, etc. Each of these bodies has an executive committee that manages its day-to-day affairs.

Communities organize themselves into a JFM Committee to protect and manage nearby forests, guided by locally prepared byelaws and micro plans. The key element in JFM is that communities have the power to manage the use of forests by members and also exclude non-members. The benefits to them is direct access and control on the use and sale of most NTFPs and a share in the income from timber as well as other intangible benefits from local ecosystem services – like water recharge, pollination, wildlife habitat etc. Thus involvement of communities in conservation of forests and wildlife is of paramount interest.

JFM has the potential to meet local subsistence needs, of fuel wood, fodder, other non-timber forest produce, small timber and timber etc., to provide livelihood through sale of produce, while at the same time, preventing degradation of the forests that provide local, national and global environmental benefits.

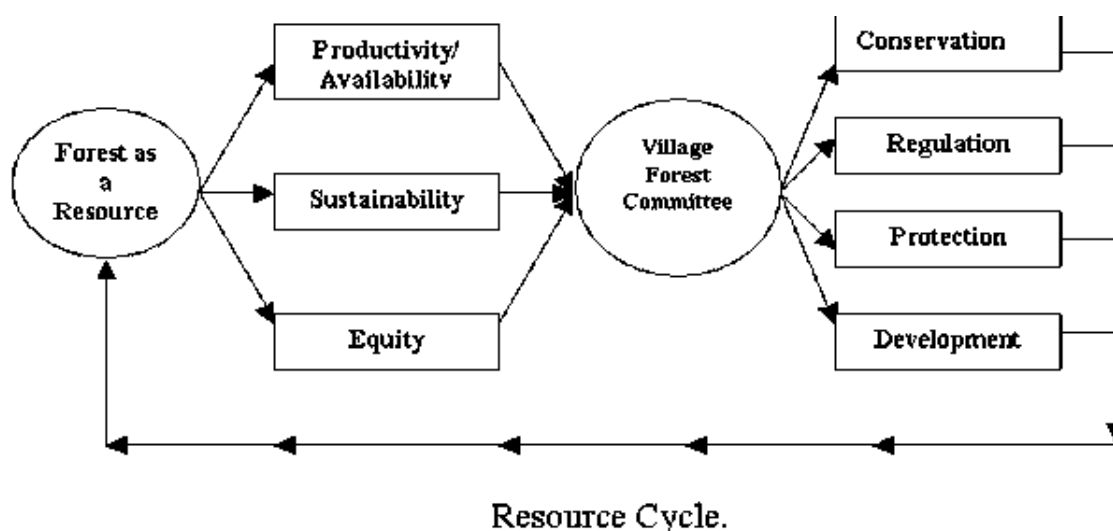


Figure 19 : Joint Forest Management

Non-wood forest products (NWFPs) have a key role in JFM efforts. With the increasing awareness of their economic potential and growing concerns for the sustainability of the resources and the distribution of the benefits derived from them, various state governments have taken over control of a number of NWFPs. This article, by looking at case studies of some selected NWFPs, questions whether this process has met its objectives - ensuring fair wages to the collectors, enhancing forest protection and increasing state revenues, for example - and examines its impact on joint forest management.



Plate 10 :
Source: <https://www.indiamike.com/>

Joint Forest Management originated in West Bengal in 1980's in Asia and Africa . The major hardwood of Arabari is *sal*, a commercially profitable forest crop. Ajit Kumar Banerjee, a silviculturalist, working for the Forest Department as the Divisional Forest Officer, was conducting trials which were constantly being disturbed by

grazing and illegal harvesting by the local populace. This process of greening the forest was brought about by setting up Joint Forest Management committees consisting of the local villagers and as result of their efforts a forest which was initially almost worthless became an economic boon to the villagers; the value of the forest area multiplied several times.

7.0 Wildlife conservation and management: Sanctuary, National Park and Biosphere Reserves

7.1 Wildlife Sanctuary

Sanctuary is an area which is of adequate ecological, faunal, floral, geomorphological, natural or zoological significance. The Sanctuary is declared for the purpose of protecting, propagating or developing wildlife or its environment. Certain rights of people living inside the Sanctuary could be permitted. Further, during the settlement of claims, before finally notifying the Sanctuary, the Collector may, in consultation with the Chief Wildlife Warden, allow the continuation of any right of any person in or over any land within the limits of the Sanctuary.

Characteristics of Wildlife Sanctuary

1. It is natural area which is reserve by a governmental or private agency for the protection of particular species.
2. Area is designated for the protection of wild animals.
3. Only animals are conserved.
4. It came under the category called "Protected Areas". The Protected Areas are declared under Wildlife (Protection) Act, 1972.
5. International Union for Conservation of Nature (IUCN) has defined its Category IV type of protected areas.

Example – Sajnekhali Bird Sanctuary; Manas Wildlife Santuary

Wildlife Sanctuaries in West Bengal

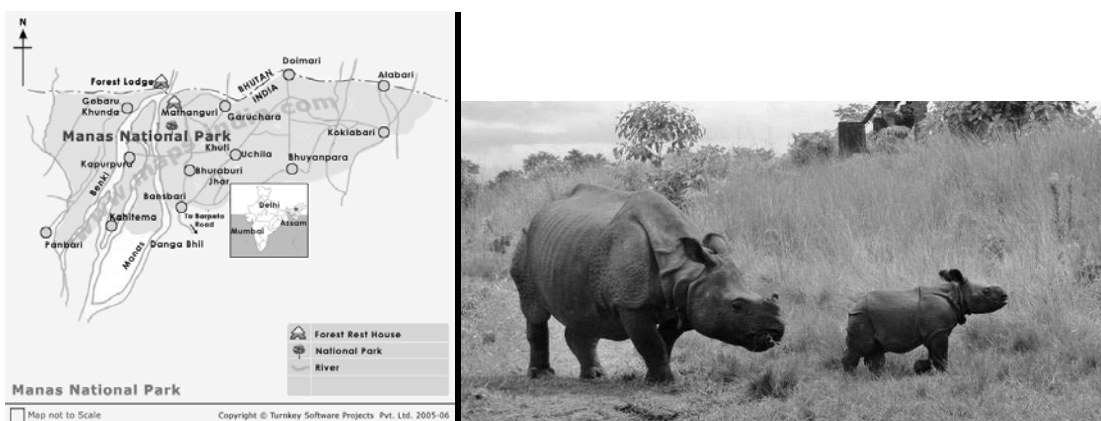
- Chapramari Wildlife Sanctuary, 1976
- Haliday Island Wildlife Sanctuary, 1976
- Lothian Island Wildlife Sanctuary, 1976

- Mahananda Wildlife Sanctuary, 1976
- Sajnakhali Wildlife Sanctuary, 1976
- Senchal Wildlife Sanctuary, 1976
- Ballabhpur Wildlife Sanctuary, 1977
- Bethuadahari Wildlife Sanctuary, 1980
- Bibhutibhushan Wildlife Sanctuary, 1980
- Ramnabagan Wildlife Sanctuary, 1981
- Chintamoni Kar Bird Sanctuary, 1982
- Jore Pokhri Wildlife Sanctuary, 1985
- Raiganj Wildlife Sanctuary, 1985
- Buxa Tiger Reserve, 1986
- Sundarbans West Wildlife Sanctuary, 2013
- Sundarbans East Wildlife Sanctuary

A Short Description of Manas Wildlife Sanctuary

Brief synthesis

Manas Wildlife Sanctuary is located in the State of Assam in North-East India, a biodiversity hotspot. Covering an area of 39,100 hectares, it spans the Manas River and is bounded to the north by the forests of Bhutan. The Manas Wildlife Sanctuary is part of the core zone of the 283,700 hectares Manas Tiger Reserve, and lies alongside the shifting river channels of the Manas River. The site's scenic beauty includes a range of forested hills, alluvial grasslands and tropical evergreen forests. The site provides critical and viable habitats for rare and endangered species, including tiger, greater one-horned rhino, swamp deer, pygmy hog and Bengal florican. Manas has exceptional importance within the Indian sub-continent's protected areas, as one of the most significant remaining natural areas in the region, where sizeable populations of a large number of threatened species continue to survive.



Plates 11 and 12 : Manas Wildlife Sanctuary, Assam

Manas is recognized not only for its rich biodiversity but also for its spectacular scenery and natural landscape. Manas is located at the foothills of the Eastern Himalayas. The northern boundary of the park is contiguous to the international border of Bhutan manifested by the imposing Bhutan hills. It spans on either side of the majestic Manas river flanked in the east and the west by reserved forests. The tumultuous river swirling down the rugged mountains in the backdrop of forested hills coupled with the serenity of the alluvial grasslands and tropical evergreen forests offers a unique wilderness experience.

The Manas-Beki system is the major river system flowing through the property and joining the Brahmaputra River further downstream. These and other rivers carry an enormous amount of silt and rock debris from the foothills resulting from the heavy rainfall, fragile nature of the rock and steep gradients of the catchments. This leads to the formation of alluvial terraces, comprising deep layers of deposited rock and detritus overlain by sandy loam and a layer of humus represented by *Bhabar* tracts in the north. The *Terai* tract in the south consists of fine alluvial deposits with underlying pans where the water table lies near to the surface. The area contained by the Manas-Beki system gets inundated during the monsoons but flooding does not last long due to the sloping relief. The monsoon and river system form four principal geological habitats: *Bhabar* savannah, *Terai* tract, marshlands and riverine tracts.

The dynamic ecosystem processes support broadly three types of vegetation: semi-evergreen forests, mixed moist and dry deciduous forests and alluvial grasslands. The dry deciduous forests represent an early stage in succession that is constantly renewed by floods and is replaced by moist deciduous forests away from water courses, which in turn are replaced by semi evergreen climax forests. The vegetation of Manas has tremendous regenerating and self-sustaining capabilities due to its high fertility and response to natural grazing by herbivorous animals.

The Manas Wildlife Sanctuary provides habitat for 22 of India's most threatened species of mammals. In total, there are nearly 60 mammal species, 42 reptile species, 7 amphibians and 500 species of birds, of which 26 are globally threatened. Noteworthy among these are the elephant, tiger, greater one-horned rhino, clouded leopard, sloth bear, and other species. The wild buffalo population is probably the only pure strain of this species still found in India. It also harbours endemic species like pygmy hog, hispid hare and golden langur as well as the endangered Bengal florican. The range of habitats and vegetation also accounts for high plant diversity that includes 89 tree species, 49 shrubs, 37 undershrubs, 172 herbs and 36 climbers. Fifteen species of orchids, 18 species of fern and 43 species of grasses that provide vital forage to a range of ungulate species also occur here.

Integrity

The property is a wildlife sanctuary with a focus on maintaining the integrity of the property as a natural area. It forms the core of a larger national park, the boundaries of which are clearly demarcated and supervised. Manas Wildlife Sanctuary is buffered on the north by the Royal Manas National Park of Bhutan and on the east and west less effectively by the Manas Tiger Reserve. Transboundary cooperation is therefore important to the effectiveness of its protection.

Protection and management requirements

The property, which has six national and international designations (i.e. World Heritage Site, National Park, Tiger Reserve (core), Biosphere Reserve (national), Elephant Reserve (core) and Important Bird Area) has the highest legal protection and strong legislative framework under the provisions of Indian Wildlife (Protection) Act, 1972 and Indian Forest Act, 1927/Assam Forest Regulation 1891. The property benefits from government support at both national and regional levels as well as involvement of national and international conservation organisations.

The property is managed under the administration of the Assam Forest Department / Bodoland Territorial Council. A comprehensive and approved Management Plan is an essential requirement, together with effective patrolling and enforcement capacity to deal with the threats of encroachment, grazing and poaching. The provision of adequate infrastructure, skilled personnel and monitoring arrangements for the property are all essential requirements. Scientific research and monitoring for habitat and invasive species management and recovery of wildlife populations is a particular imperative for management to ascertain and maintain the Outstanding Universal Value of the property. The property is home to 400 varieties of wild rice, also making the management of its biodiversity values of high importance to food security.

Provision of effective tourism facilities, visitor information and interpretation is also a priority for the park management. A sustainable financing mechanism needs to be ensured to provide the necessary financial resources for the long term management of the property. The surrounding buffer zones are managed on a multiple use basis, and a balance is required between conservation and resource extraction in the management of these areas.

Involvement of local communities who live and make use of the areas adjacent to the reserve in protection efforts for the property is essential, and a key management objective is to enhance their engagement and awareness in the interest of the preservation of the property. There is potential to extend the property to coincide with the boundaries of the national park of which it forms the core. The establishment of a trans-boundary world heritage property across the Indian and Bhutanese Manas Tiger Conservation Landscape would enable greater coordination and cooperation in the management of habitat and wildlife populations and would strengthen protection as well.

7.2 National Park

National park is an area which is strictly reserved for the betterment of the wildlife & biodiversity, and where activities like developmental, forestry, poaching, hunting and grazing on cultivation are not permitted. In these parks, even private ownership rights are not allowed. Their boundaries are well marked and circumscribed. They are usually small reserves spreading in an area of 100 sq. km. to 500 sq. km. In national parks, the emphasis is on the preservation of a single floral or faunal species.

India's first national park was established in 1936 as Hailey National Park, now known as Jim Corbett National Park, Uttarakhand. By 1970, India only had five national parks. In 1972, India enacted the Wildlife Protection Act and Project Tiger to safeguard the habitats of conservation reliant species.

Further federal legislation strengthening protection for wildlife was introduced in the 1980s. As of July 2018, there were 110 national parks encompassing an area of 40,501 km² (15,638 sq mi), under protected areas of India category II comprising 1.23% of India's total surface area.

Characteristics of National Park

1. Reserve area of land, owned by the government.
2. Area is protected from human exploitation, industrialization and pollution.
3. No cutting, Grazing allowed, Outside Species is allowed.
4. It came under the category called "Protected Areas". The Protected Areas are declared under Wildlife (Protection) Act, 1972.
5. Conservation of 'wild nature' for posterity and as a symbol of national pride.

6. International Union for Conservation of Nature (IUCN), and its World Commission on Protected Areas, has defined its Category II type of protected areas.

Example – Jaldapara National Park, West Bengal; Yellowstone National Park, USA etc.

National Parks (According to wildlife protection act 1972)

Declaration of National Parks – (1) Whenever it appears to the State Government that an area, whether within a sanctuary or not, is, by reason of its ecological, faunal, floral, Geo-morphological, or zoological association or importance, needed to be constituted as a National Park for the purpose of protection & propagating or developing wildlife therein or its environment, it may, by notification, declare its intention to constitute such area as a National Park.

(1) Provided that where any part of the territorial waters is proposed to be included in such National Park, the provisions of Sec.26A shall, as far as may be, apply in relation to the declaration of a National Park as they apply in relation to the declaration of a sanctuary.

- The notification referred to in sub-section (1) shall define the limits of the area which is intended to be declared as a National Park.
- Where any area is intended to be declared as a National Park, the provisions of Sec. [19 to 26-A (both inclusive except clause (c) of sub-section (2) of section 24)] shall, as far as may be, apply to the investigation and determination of claims and extinguishment of rights, in relation to any land in such area as they apply to the said matters in relation to any land in a sanctuary.
- When the following events have occurred, namely
- the period for preferring claims has elapsed, and all claims, if any, made in relation to any land in an area intended to be declared as a National Park, have been disposed of by the State Government, and
- all rights in respect of lands proposed to be included in the National Park have become vested in the State Government

the State Government shall publish a notification specifying the limits of the area which shall be comprised within the National Park and declare that the said area shall be a National Park on and from such date as may be specified in the notification.

- No alteration of the boundaries of a National Park shall be made except on a resolution passed by the Legislature of the State.
- No person shall, destroy, exploit, or remove any wildlife from a National Park or destroy or damage the habitat or any wild animal or deprive any wild animal or its habitat within such National Park except under and in accordance with a permit granted by the Chief Wildlife Warden and no such permit shall be granted unless the State Government, being satisfied that such destruction, exploitation, or removal of wildlife from the National Park is necessary for the improvement and better management of wildlife therein, authorizes the issue of such permit.
- No grazing of any [livestock] shall be permitted in a National Park and no livestock shall be allowed to enter except where such [livestock] is used as a vehicle by a person authorized to enter such National Park.

- The provisions of secs. 27 and 28, secs.30 to 32 (both inclusive), and CIS, (a), (b) and (c) of [Sec.33, 33A] and sec.34 shall, as far as may be, apply in relation to a National Park as they apply in relation to a sanctuary.

List of National Parks in West Bengal

Sl. No.	Name of National Park	Year of Notification	Total Area (km ²)
1	Buxa National Park	1992	117.10
2	Gorumara National Park	1992	79.45
3	Neora Valley National Park	1986	159.89
4	Singalila National Park	1986	78.60
5	Sunderban National Park	1984	1330.10
6	Jaldapara National Park	2014	216.51

7.3 Biosphere Reserves

Biosphere reserves are sites established by countries and recognized under UNESCO's Man and the Biosphere (MAB) Programme to promote sustainable development based on local community efforts and sound science. The programme of Biosphere Reserve was initiated by UNESCO in 1971. The purpose of the formation of the biosphere reserve is to conserve in situ all forms of life, along with its support system, in its totality, so that it could serve as a referral system for monitoring and evaluating changes in natural ecosystems. The first biosphere reserve of the world was established in 1979, since then the network of biosphere reserves has increased to 631 in 119 countries across the world.

Biosphere reserves have three interrelated zones that aim to fulfil three complementary and mutually reinforcing functions:

- **The core area(s)** comprises a strictly protected ecosystem that contributes to the conservation of landscapes, ecosystems, species and genetic variation.
- **The buffer zone** surrounds or adjoins the core areas, and is used for activities compatible with sound ecological practices that can reinforce scientific research, monitoring, training and education.
- **The transition area** is the part of the reserve where the greatest activity is allowed, fostering economic and human development that is socio-culturally and ecologically sustainable.

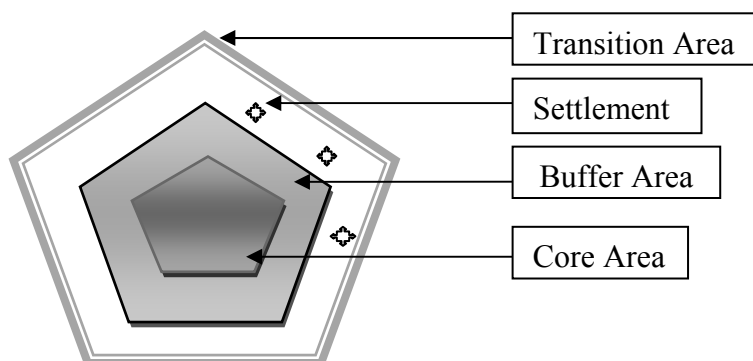


Figure 20 : Biosphere Reserve

Characteristics of Biosphere Reserve

1. Notified areas which cover a larger area of land which may cover multiple National Parks, Sanctuaries and reserves as well.
2. Areas are meant for conservation of biodiversity of a specific area.
3. Three areas: Core, Buffer & Marginal. No outside Species allowed Conservation & research purpose.
4. It is internationally recognized within the framework of UNESCO's Man and Biosphere (MAB) programme and nominated by national governments.
5. The Ministry of Environment and Forest provides financial assistance to the respective State governments for conservation of landscape and biological diversity and cultural heritage.
6. Achieving the three interconnected functions: conservation, development and logistic support
7. Outpacing traditional confined conservation zones, through appropriate zoning schemes combining core protected areas with zones where sustainable development is fostered by local dwellers and enterprises with often highly innovative and participative governance systems,
8. Focusing on a multi-stakeholder approach with particular emphasis on the involvement of local communities in management,
9. Fostering dialogue for conflict resolution of natural resource use,
10. Integrating cultural and biological diversity, especially the role of traditional knowledge in ecosystem management,
11. Demonstrating sound sustainable development practices and policies based on research and monitoring,
12. Acting as sites of excellence for education and training,
13. Participating in the World Network

Example – Sunderban Biosphere Reserves, Nokrek Biosphere Reserves etc.

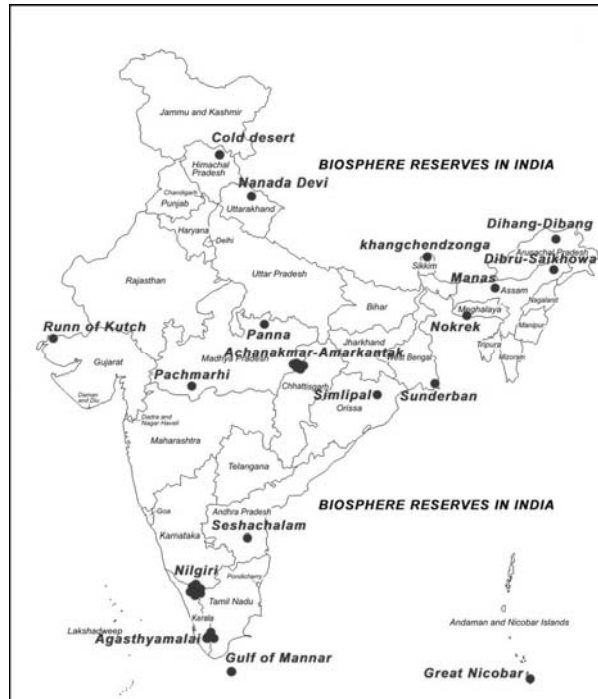


Figure 21 : Biosphere Reserves in India
Plate 13 : Nilgiri Biosphere Reserve

8.0 Dams And Development – Displacement And Rehabilitation Issues

"If you are to suffer, you should suffer in the interest of the country."

Jawaharlal Nehru

Since India's independence in 1947, there has been a surge of economic development activities in the form of massive infrastructure development projects such as the construction of dams for power and irrigation, the building of roads, urbanization, mining, building of thermal power plants, etc. Proponents of large dams argue that only these types of massive projects can improve India's economy and the lives of millions of people.

Growth of economy and expansion of cities influences the need for investments as well as infrastructure expansion. The increasing investment and expansion of infrastructure further stimulates demand for land for new industrial estates, for services, commercial estates, communication, and road networks and for transportation corridors. To accommodate such development, land redevelopment becomes a necessity. However, much of that land is already populated which makes displacement and resettlement of the existing population a prominent feature of development projects in the urban setting. Thus, the flip side of this sort of development is that it has displaced more than 42 million people in the country.

Displacement involves physical eviction from a dwelling and the expropriation of productive land and other assets to make possible an alternative use. Development –induced population displacement, is the upheaval of communities to make way for large dams, industrial zones, transportation routes, game parks and commercial forestry, concerns the balance between the benefits of infrastructural development and the costs and pains of being uprooted and consequently resettled, and the risk of impoverishment carried by those forcibly displaced.

The poorest and most marginalized people are generally hit the hardest by displacement, most often without adequate compensation. Many displaced families have been displaced three or four times. “In India, 50 million people have been displaced in the last 50 years in the name of ‘national’ interest“. [Parshuram Ray, Development Induced Displacement in India, SARWATCH Vol. 2 No. 1 July 2000).

Official figures of the number of displaced people are just underestimates. This is usually done to present a good cost benefit ratio to project clearance agencies and funders. The World Bank has put the number of people displaced by the Farakka Super Thermal Power plant in West Bengal as 63325 while Indian government figures suggest that no one was displaced. [Walter Fernandes, Displacement - What is all the fuss about? Humanscape, November 1999]. In the case of the Bargi dam, the number of villages submerged increased from the initial figure of 101 to 162. Likewise, in the case of various other large dams in the country, the number of submerged villages has increased and estimates of displaced villages have failed, which lead to unplanned displacement.

Displacements due to dams and canals have been traumatic and dehumanising. The displaced family's livelihood, their family, kinship systems, cultural identity and informal social networks were badly affected and disrupted. The condition of the women is even more traumatic. Lack of policy framework and social securities has made them insecure and psychologically very weak.

The monetary compensation paid to the displaced was not enough to sustain their livelihoods. The lame assurances by the government have never become a reality and it has led to tragic consequences. Large-scale dam building has been able to deliver very little in terms of benefits. Many projects are able to irrigate just 20% of the command area but the harm they do to the environment and people is immense.

8.1 Displacement due to Bargi Dam Construction on the Narmada River

Bargi Dam is one of the first completed dams out of the chain of 30 major dams to be constructed on Narmada River in Madhya Pradesh, India. Two major irrigation projects, named Bargi Diversion Project and Rani Avantibai Lodhi Sagar Project, have been developed by Bargi Dam. The Narmada is the largest river in Madhya Pradesh, flowing towards the west and falling in the Arabian Sea. Its total length is 1312 km of which it covers 1072 km in Madhya Pradesh.

The Central Water and Power Commission conceptualized the proposal of this dam construction in 1968 envisaging irrigation in 2,980 square kilometres and hydropower generation capacity of 100 MW (2x45 MW + 2x5 MW). Later the Bargi diversion scheme was planned, increasing the total irrigation potential to 4,370 square kilometres. The dam construction work started in 1974 and was completed in 1990 when the dam was filled to its complete capacity. Although the proposed power generation was 105 MW, currently only 90 MW is being generated in this Hydro-Power Generation Plant. Two independent units of 45 MW each have been set up and they function mainly during the evening peak in demand.

The height of the dam is 69 m and length 5.4 km. A lake of about 75 km in length and 4.5 km width, spreading over 267.97 km² in Jabalpur, Mandla and Seoni districts, is formed when the water is impounded up to the dam FRL of 422.76 m.

Displacement and Rehabilitation



Plate 14 : Bargi Dam, Madhya

The construction of the Bargi Dam (1971-1990) on the river Narmada affected 27,432 ha of land and displaced 5,475 families. Initially provision was made only for payment of compensation for land and property. The lack of planning for human problems led eventually to an agitation lasting over several years.

On receiving complaints from the affected people the Commissioner of Social Welfare intervened in 1986 and convinced the state to prepare a rehabilitation plan of Rs.100 million (US\$ 2 million). Delay and mismanagement, including rehabilitation work in places not affected by the dam, led to the displaced people coming together to form a Union.

Demonstrations began in 1992, demanding fishing rights and protesting against the complete filling up of the dam. In 1994, the Chief Minister met the displaced people, accepted responsibility for rehabilitation, and agreed to some of the demands. To speed up the works, a divisional level planning committee was set up which drew up a rehabilitation plan, but its implementation was held up due to delays in obtaining funding.

In 1996, violent demonstrations resumed demanding reduction of the reservoir water level. The Chief Secretary visited the affected area, met the Union, and agreed to demands. The cycle of non-implementation, agitation and subsequent agreement to some demands was repeated in 1997.

Since then rehabilitation work has been carried out in cooperation between the Union and the government. The state has been providing about Rs.14.5 million (US\$ 0.3 million) every year since 1998.

A number of rehabilitation steps have been completed, including distribution of residential plots, allotment of drawdown land and construction of infrastructure as per the master plan prepared in consultation with the Union

Rethinking the Issue of ‘Development’

While referring to the acquisition of land for development purposes, it is important to understand what constitutes, development’ itself. Since last few decades, development has been looked at as something beyond a mere growth in GDP, that is, an overall Human Development. The Human Development Reports look at ‘Development’ as increasing people’s choices. There have also been theorized certain basic needs or basic capabilities that all people are entitled to, for a society to ensure true development. If this be so, it is essential that the laws of a democratic country ensure that due to acquisition of land for the growth of few, the displaced persons are not made worse-off. Reference may be made to criticism of large scale development projects, which have been increasingly criticized by different institutions and by theorists such as E.F. Schumacher.

In the context of India, the displacement caused due to dams etc. has often been a product of the ideologies like Nehruvian socialism. There is something intuitively and morally wrong about the idea of having development at the cost of some persons’ well-being. At this juncture, it is relevant to consider the Gandhian approach of Inclusive Development, which is a decentralized and less anthropocentric approach, and aims at internalizing happiness through moral obligations. Gandhi also replaced the idea of rights with duties. One of the moral gaps that have often been exploited by those in power has been due to the idea that there is no duty unless someone has proved his/her right in the court of law. Why should duties presuppose the existence of rights? This is a larger philosophical issue, and shall not be addressed here, but it is still worth-while for those in power to put a greater emphasis on their duties, and make political and policy decisions only after fully realizing the burdens of these moral and legal duties.

9.0. Environmental Implications of River Linking Project

9.1 Introduction

The availability of freshwater at various spots on the Earth’s terrestrial surface will continue to be determined by the hydrological cycle, till such a time when technologies like desalination of seawater is practiced on a reasonably extended scale. The rapid growth in the demand of freshwater driven by growth in the global population and of the economies, has led to this natural resource becoming scarce in many parts of the world. As a result, the ratio between the number of people and the available water resource is worsening day by day. By 2020, the global population is projected to be in the range of 7.3 to 7.9 billion, which is 50 per cent larger than that in 1990 (UN, 2006). Because of this rapidly growing human population, the world may see more than a six-fold increase in the number of people living in conditions of water stress - from 470 million today to 3 billion in 2025. In the global picture, India is identified as a country where water scarcity is expected to grow considerably in the coming decades. Further, drought conditions resulting from climatic variability cause considerable human suffering in many parts of the country, in the form of scarcity of water for both satisfaction of domestic needs and for crop protection. The project for interlinking of rivers of India emanates from a desire of the political leadership of the country to bring a permanent solution to the negative impacts of drought and water shortages in these parts (IWRS,

1996). Such a desire is, without question, worthy of applause because satisfaction of domestic water needs should be considered as a human right and be given the top priority. The interlinking project is based on the National Perspective for Water Development as framed by the Ministry of Water Resources in August 1980. The National Water Development Agency (NWDA) was set up in 1982 to carry out detailed studies in the context of the National Perspective. In late 2002, the proposals of the NWDA started to receive great media attention after the Supreme Court of India passed an order in a Public Interest Litigation, that the government should complete the construction of the interlinking project by 2016.

The Indian Rivers Inter-link is a proposed large-scale civil engineering project that aims to effectively manage water resources in India by linking Indian rivers by a network of reservoirs and canals and so reduce persistent floods in some parts and water shortages in other parts of India. The Inter-link project has been split into three parts: a northern Himalayan rivers inter-link component, a southern Peninsular component and starting 2005, an intrastate rivers linking component.

9.2 Objectives

The average rainfall in India is about 4,000 billion cubic metres, but most of India's rainfall comes over a 4-month period – June through September. Furthermore, the rain across the very large nation is not uniform, the east and north gets most of the rain, while the west and south get less. India also sees years of excess monsoons and floods, followed by below average or late monsoons with droughts. This geographical and time variance in availability of natural water versus the year round demand for irrigation, drinking and industrial water creates a demand-supply gap that has been worsening with India's rising population.

Proponents of the rivers inter-linking projects claim the answers to India's water problem is to conserve the abundant monsoon water bounty, store it in reservoirs, and deliver this water – using rivers inter-linking project – to areas and over times when water becomes scarce. Beyond water security, the project is also seen to offer potential benefits to transport infrastructure through navigation, as well as to broadening income sources in rural areas through fish farming.

9.3 Major River Inter-Linking Projects

The Inter-linking of Rivers Project: In order to equalize the unequal distribution of water resources in time and space, and to eliminate the twin problem of flood-drought, the government of India proposed the National Perspective Plan (NPP) in 1980 for development of water resources. The NPP outlined a plan, detailing inter-basin transfer of water from “water-surplus” areas to “water-deficit” areas. This inter-basin transfer of water is called the Interlinking of Rivers Project (ILRP). In order to materialize the ILRP, the National Water Development Agency (NWDA) was set up in 1982 with the mandate of carrying out water balance and other studies on a scientific and realistic basis for optimal utilization of water resources. The NWDA has identified 16 link proposals for the Peninsular and 14 for the Himalayan components for preparation of feasibility reports. The ILRP envisages linking 37 major rivers with 30 artificial link canals (totalling 14,900 km length), to transfer waters from surplus

watersheds (e.g. Ganges-Brahmaputra) to the water-deficit watersheds (e.g., Mahanadi, Godavari, Cauvery, and Tapi) in the southern and western parts of the country.

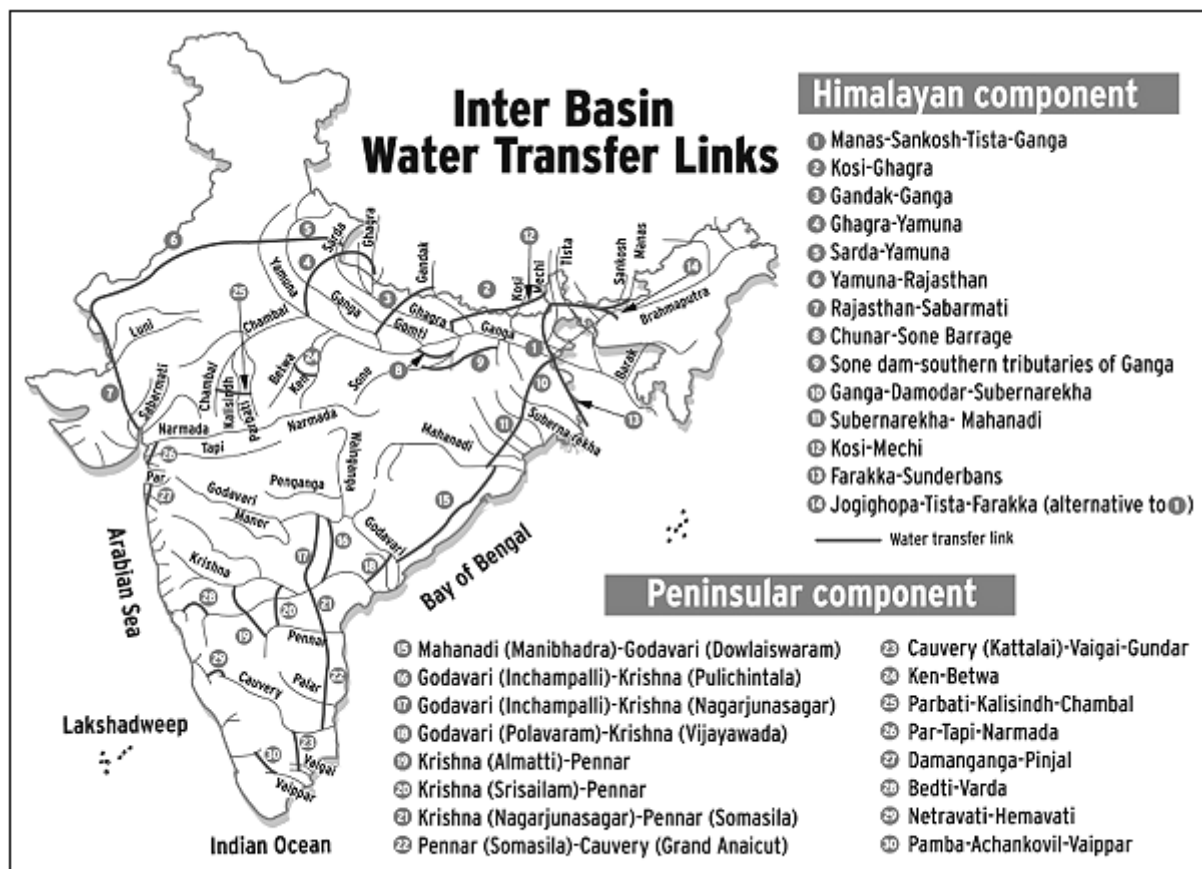


Figure 22 : Inter Basin Water Transfer Links

Source: Mehta & Mehta, 2013: 139

A. Himalayan Rivers Inter-Link Belt

- Ghaghara-Yamuna link
- Sarda-Yamuna link
- Yamuna-Rajasthan link
- Rajasthan-Sabarmati link
- Kosi-Ghaghara link
- Kosi-Mechi link
- Manas-Sankosh-Tista-Ganga link
- Jogighopa-Tista-Farakka link
- Ganga-Damodar-Subernarekha link
- Subernarekha-Mahanadi link
- Farakka-Sunderbans link
- Gandak-Ganga link
- Chunar-Sone Barrage link
- Sone dam-Southern tributaries of Ganga link

B. Peninsular Inter-Linking Projects

- Interlinking of Mahanadi-Godavari-Krishna-Palar-Pennar-Kaveri,
- Interlinking of West Flowing Rivers, North of Mumbai and South of Tapi,
- Inter-linking of Ken with Chambal, and
- Diversion of some water from West Flowing Rivers

C. Inter-state River-Linking Projects

India approved and commissioned NDWA in June 2005 to identify and complete feasibility studies of intra-State projects that would inter-link rivers within that state.[28] The Governments of Nagaland, Meghalaya, Kerala, Punjab, Delhi, Sikkim, Haryana, Union Territories of Puducherry, Andaman & Nicobar islands, Daman & Diu and Lakshadweep responded that they have no intrastate river connecting proposals.

9.4 The Concept of ‘Surplus’ River Basins

The starting point for the interlinking project is the subjective concept of the availability of ‘surplus’ flows in some river basins. In the conceptual framework of reductionist engineering it will be a win-win situation if one can simply utilize “...the water otherwise going to waste in the surplus river basins” (NCIWRDP, 1999a: p.181). The official methodology for working out whether a basin has any ‘surplus’ or not, is based on an unpublished paper by Mohile et al. (1998). In this approach, the overall surface water availability in a basin/sub-basin is assessed both at 75 per cent and 50 per cent dependability’s. These are compared with the estimated water requirements for various uses, viz; irrigation, domestic supplies, industrial requirements, hydropower and salinity control, say by 2025. The process for the assessment of irrigation, domestic and industrial needs are given in some details in the Report of the Working Group on Inter-basin Transfer of Water (NCIWRDP, 1999b: p.30). Interestingly, there is no information in this Report on how the assessment of the water need for salinity control or other water needs for the continuation of diverse ecosystems services provided by water in the various parts of the basin, would be made.

9.5 Impact of Inter-Linking River Projects on the Environment

A. Environmental Refugees

The term ‘environmental refugees’ is now widely used within both environmental and the humanitarian aid disaster relief communities. There are refugees from floods, toxic spills and dump sites, desertification, hydroelectric projects, strip mining, radon and other radiation exposure, severe logging, soil erosion, agricultural land abuse, disease epidemics, defoliation, land mines, and other unwitting or intentional human activities. Dams cause permanent changes in the land use patterns and in the habitats of people those who are living in the area nearby the site of dams. This is also known as ‘displacement due to development’. Dams and other developmental activities such as; construction of canals and roads, rails are examples of the human induced environmental disasters.

B. Issue of Forest Hacking

The impoundment in the reservoir area leads to the loss of forested tracts. Upper reaches of valleys are store house of biodiversity and are contributing to our most of flora and fauna. But due to the construction of dams and link canals these ecologically most hostile areas are in danger.

C. Issue of Sedimentation

Another issue that should be addressed in the process of linking of rivers the rate of sedimentation in reservoir on a longer term basis, it is a matter of serious concern that the life span and benefits of several irrigation projects has significantly reduced due to rapid rate of sedimentation.

D. Water Logging And Salinization

The sustainability of any developmental project vitally hinges on its ability to maintain the essential ecological factors. From the point of view of enhancing the agricultural production, water-logging in the command and salinization of soils are two most significant out-growths of perennial irrigation. The impounding of such large amounts of water and the existence of permanent water-logging in the command has brought with it malaria in its most dreadful forms.

E. Issue of River Pollution

Most Indian rivers pass through agricultural areas that use pesticides. This makes leaching from agricultural fields the most non-point -unspecified, and therefore, not measurable accurately-sources of pollution to the aquatic environment. Environmentalist have said that most of India's rivers, the main source of water and sacred for the majority of the population, are already dead, because millions of industrial effluents and domestic flow into them daily.

9.6 Conclusion

The interlinking project, as described now, looks like a set of linkages, developed primarily for irrigation, but looking for diverse other justifications, of drought proofing, drinking water supply, flood control, etc. Its idea of providing domestic water supply to large urban areas in dry regions is very plausible. Other claims are not that convincing. The Himalayan component is not based on any open and professionally assessed knowledgebase. This is a source of serious concern. In the interest of the people of India, justifications put forward for such a gigantic project should be assessed in an open and professional manner. There is a clear need for examining the presuppositions on which the whole interlinking project has been put. The need to study the feasibility of the independent links will arise only after the premises are found agreeable. If the old practice of getting feasibility studies on water related projects conducted away from the public view is continued, it will be against the expectations of the changing times of openness and transparency.

10.0 Dimension of Environmental Movements in India

The environmental movement (sometimes referred to as the ecology movement), also including conservation and green politics, is a diverse scientific, social, and political movement for addressing environmental issues. In the last forty years, people in various regions of India have formed non-violent action movements to protect their environment, their livelihood, and their ways of life. These

environmental movements have emerged from the Himalayan regions of Uttar Pradesh to the tropical forests of Kerala and from Gujarat to Tripura in response to projects that threaten to dislocate people and to affect their basic human rights to land, water, and ecological stability of life-support systems. They share certain features, such as democratic values and decentralized decision making, with social movements operating in India. Environmentalists advocate the sustainable management of resources and stewardship of the environment through changes in public policy and individual behaviour. Some of the popular environmental movements in India are:

- The Chipko Movement
- Bishnoi Movement
- Narmada Bachao Andolan
- Appiko Movement
- Silent Valley Movement
- Tehri Dam Conflict
- Save Ganga Movement

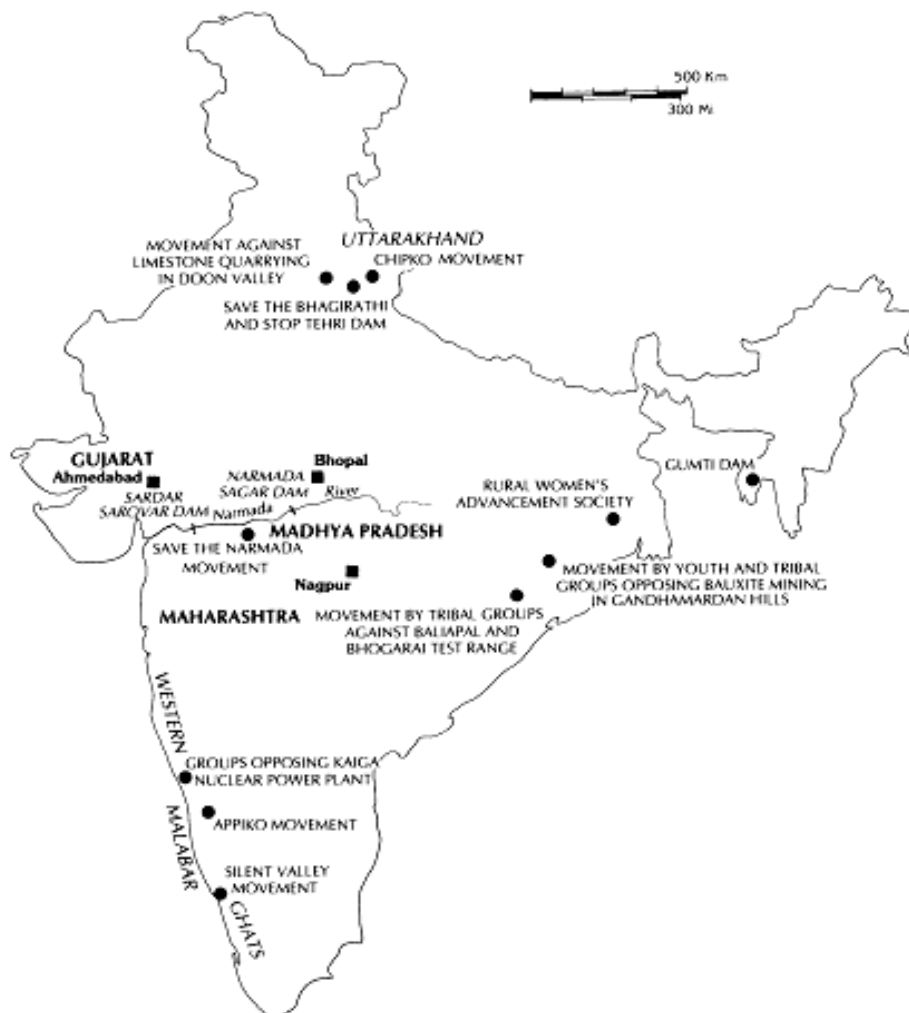


Figure 23 : Location of Environmental Movements in India

Source: Karan, 1994: 33

10.1 Chipko Movement

The genesis of the environmental movement in India can be traced to the *Chipko* movement (1973) in



Plate 15 : Chipko Movement
Source: <https://indianexpress.com/>

Garhwal region in the new state of Uttaranchal. In fact, between 1970s and 1980s there were several struggles in India around issues of rights to forest and water which raised larger ecological concerns like rights of communities in forest resources, sustainability of large scale environmental projects like dams, issues of displacement and rehabilitation etc.

The word *chipko* means to stick to or to hug and refers to the method used

to protect the trees of the Himalaya from commercial timber cutters who have devastated the forests. The movement's activists embrace the tree trunks to interpose their bodies between the trees and the axe-men. The *Chipko* movement is located in the mountainous northern segment of Uttar Pradesh, immediately west of Nepal.

The first Chipko action took place spontaneously in April 1973 in the village of Mandal in the upper Alakananda valley and over the next five years spread to many districts of the Himalayas in Uttar Pradesh. It was sparked off by the government's decision to allot a plot of forest area in the Alaknanda valley to a sports goods company. This angered the villagers because their similar demand to use wood for making agricultural tools had been earlier denied. With encouragement from a local NGO (non-governmental organization), DGSS (Dasoli Gram Swarajya Sangh), the women of the area, under the leadership of an activist, Chandi Prasad Bhatt, went into the forest and formed a circle around the trees preventing the men from cutting them down.

The success achieved by this protest led to similar protests in other parts of the country. From their origins as a spontaneous protest against logging abuses in Uttar Pradesh in the Himalayas, supporters of the Chipko movement, mainly village women, have successfully banned the felling of trees in a number of regions and influenced natural resource policy in India. Dhoom Singh Negi, Bachni Devi and many other village women, were the first to save trees by hugging them. They coined the slogan: 'What do the forests bear? Soil, water and pure air'. The success of the Chipko movement in the hills saved thousands of trees from being felled.

10.2 Bishnoi Movement

Bishnoi (also known as *Vishnoi* and *Prahladapanthi*) is a Hindu religious sect found in the Western Thar Desert and northern states of India.

History

In the year 1730 AD, when Maharaja Ahay Singhji, ruler of Marwar (Jodhpur) State desired to construct a new royal mansion, namely, Phool Mahal For this purpose, some quantity of limestone was brought from nearby quarries but it had to be burnt before use in other words some firewood was

needed. In view of this, the king sent his troops to cut the trees. Thus, the troops reached a Bishoni village called Khejali about 21 km away from Jodhpur city. This village was having rich green patches while comparing with other parts of the area as they been protecting and nourishing since after launching of the Bishnoi cult in the village. Firstly, the troops approached the Ramuji Bishoni's residence where a huge sprawling Khejri (*Prosopis cineraria*) tree was being grown. At that time, Ramuji went to his agriculture field and his wife, namely, Amrita Devi and their daughters, namely, Asu, Ratni, and Bhagu Bai were at home.

During the time, Amrita Devi felt that some commotion was going on outside the house, accordingly, she had instructed the daughters to find the matter. They observed that the troops were preparing to cut the green trees which were in front of their house. Subsequently, Amrita Devi resisted cutting of the green trees as it was prohibited in their cult. However, the troops offered the gold and money but she was not succumbing to temptation for bribe. Further, she stated that she considered it as an act of ignominy and insult to her religious faith. Furthermore, she expressed that she rather give away her life to save the green trees. Furthermore, she said, "If a tree was saved from cutting at the cost of one's head, she was ready for that". Subsequently, she offered her head for sacrifice. The axes were cut the neck of Amrutha Devi and her daughters.

This news scattered to the other *Bishnois* villages like a wild fire. The *Bishnois* of eighty-three villages rushed to the spot and tried to protect the trees but it was in vain. Subsequently, they took the decision that each tree should be embraced by a *Bishnoi* volunteer like *Chipko* movement occurred in the 20th century. Like this, they sacrificed their lives for protecting the green trees. In the beginning of sacrifice, old people started embracing the trees, in this way, many old people sacrificed their lives for the noble cause, however, and the trees were being fallen. Meanwhile, the *Hakim* (head of the soliders) commented that *Bishnois* were getting rid of their old people in this manner, then, young men, women, just married, unmarried, rich and poor sacrificed their lives by embracing the trees. Ultimately, three hundred sixty three people sacrificed their lives for these noble causes of protecting trees in their village vicinity.

After this the genocide, the troops went back to Jodhpur and informed the same to the king. He apologized to the *Bishnois* for occurrence of the incident. In addition, he issued a royal decree, engraved on a copper plate ordering the following – All cutting of green trees and hunting of animals within the revenue boundaries of *Bishnoi* villages was strictly prohibited; It was also ordered that if by mistake any individual violated this order, severe prosecution and penalty could be imposed; Even the members of the ruling family should not shoot wild animals in and around Bishnoi villages.

10.3 Save Narmada Movement

Narmada Bachao Andolon (NBA) is a social movement consisting of adivasis, farmers, environmentalists and human rights activists against the number of large dams being built across the Narmada River, which flows through the states of Madhya Pradesh, Gujarat and Maharashtra. Sardar Sarovar Dam in Gujarat is one of the biggest dams on the river and was one of the first focal points of

the movement. It is one of the many dams under the Narmada Dam Project. The main aim of the project is to provide irrigation and electricity to people in these states.

The people started the Narmada Bachao Andolan with the goal of saving and protest the River Narmada because it was the primary assist for the people. The World Bank was not providing proper



Plate 16 : Save Narmada Movement
Source: <https://www.narmada.org>

rehabilitation and resettlement for the people, so poor people have stepped for the Andolan, to protest the Narmada River. The people of the region were not getting the proper settlement in their area because there was the displaced by the construction of Sardar Sarovar Dam. After that, the movement of Narmada Bachao Andolan converted from its focus on the preservation of the environment and the ecosystems of the valley. There was some destruction for the construction of the dam; it was intended to irrigate large tracts of land in Gujarat.

While the environmentalists were raising concerns over the government's decision to go ahead with construction of dams including Sardar Sarovar on Narmada, Medha Patkar, a Ph.D. student visited some of the villages to be affected by the river valley development programme in 1985. Following her visit, Medha Patkar submitted her critique of the project to the government espousing the cause of the displaced people who had not been rehabilitated or "informed" properly about the government's plan. Medha Patkar also tried to impress upon the World Bank, which stopped funding the Sardar Sarovar Dam in 1994. When things did not go to the satisfaction of the activists, Medha Patkar dropped her PhD study and along with veteran activist Baba Amte led the Narmada Bachao Andolan (Save Narmada Movement) or the NBA. Medha Patkar undertook several fasts for weeks. At times, she remained immersed along with her supporter in the Narmada water.

10.4 Conclusion

This self-learning material contains different environmental issues which are of paramount significance in Geography. It started with the population-resource relationship in which the concepts of over-population, under-population and optimum population have been explained. Ackerman's population-resource region has then been presented in relation to population-resource-technology relation. Then it has presented a number of global environmental issues. Three issues, namely, greenhouse effect and global warming, acid rain, and ozone hole depletion have been presented here. After this, it has explained the concept of ecological footprint and sustainable development. It also shows the sustainable development goals. Then, the roles of IUCN, UNDP, UNEP, IPCC, UNFCCC have been explained especially in relation to environmental concerns.

The objectives, strategies and positive outcomes of agroforestry, social forestry and Joint Forest Management have been presented. It also shows the wildlife conservation strategy through wildlife sanctuary, national park and biosphere reserve. The inter-linking river project is of much concern at this right time. Environmental implications of these interlinking river projects have been presented in this SLM. Finally, a number of environmental movements which took place in different parts of India at different time have been discussed in this SLM.

11.0 Self-Assessment Tests

- 1) Define carrying capacity.
- 2) What are the effects of over-population?
- 3) What is optimum population? Is optimum population a reality or an ideal situation?
- 4) Following Ackerman, divide the world into population-resource regions. Bring out the characteristics of each region.
- 5) Identify and list major environmental issues.
- 6) Write a short note on global warming – its causes and consequences.
- 7) Which gases are known as ‘greenhouse gases’?
- 8) What do you mean by greenhouse effect of the atmosphere?
- 9) What are the reasons of acid rain?
- 10) Explain the role of IUCN in the conservation of Nature?
- 11) What are the objectives for the river linking projects? Discuss the environmental effects of these projects.
- 12) What were the reasons behind the Bishnoi movement?
- 13) Which benefits are expected from agro-forestry?
- 14) Narrate the influences of Arabari Project on the social forestry projects of India.
- 15) What are the differences between agro-forestry and social-forestry?
- 16) Explain the role of IUCN in conservation of rare wild-lives.
- 17) Explain the issue of displacement due to construction of dam with suitable example from India.
- 18) What do you mean by ecological foot print?
- 19) Bring out the concept of sustainable development.
- 20) Write the objectives and pillars of sustainable development.
- 21) What are the major strategies of social forestry.
- 22) Write the role of UNDP in the conservation of Nature.
- 23) What is biosphere reserve?

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Disclaimer

This self-learning material is based on different books, journals and web-sources.

GROUP – GEO207T.2:

GEOGRAPHY OF RESOURCES AND HAZARDS

(Credit – 2; Marks - 50: Internal Evaluation – 10 + Semester-end Examination - 40)

2.1 INTRODUCTION:

Hazards and disasters both natural and anthropogenic hazards and disasters such as Tropical cyclones (prediction, precaution and mitigation), Marine/ tectonic hazard: Tsunami (prediction, precaution and mitigation) Hydrological hazards: Flash floods in Himalayan region and floods are major concern for geographers. Sources, impacts and mitigation measures of nuclear hazard, radio-active contamination, CFC, plastic hazard, lead, arsenic and fluoride contaminations are also studied by geographers. Hence, this section aims to introduce these topics to students so that they can have an idea about the causes and consequences of these phenomena.

2.2 LEARNING OBJECTIVES

The present section aims to introduce the following topics:

- Concept and types of hazards and disasters
- Assessment of risk and vulnerability
- Concepts of hazard and disaster management
- Climatic hazards: Tropical cyclones (prediction, precaution and mitigation)
- Marine/ tectonic hazard: Tsunami (prediction, precaution and mitigation)
- Hydrological hazards: Flash floods in Himalayan region and floods in southern part of West Bengal
- Sources, impacts and mitigation measures of nuclear hazard and radio-active contamination, CFC and plastic hazard
- Sources, impacts and mitigation measures of lead, arsenic and fluoride contaminations

2.3 ASSESSMENT OF PRIOR KNOWLEDGE

Basic understanding of hazards and disasters

Sources and impact of major pollutants

2.4 LEARNING ACTIVITIES

In the present section the concept and types of hazards and disasters, assessment of risk and vulnerability will be discussed. Mechanism and distribution of major natural and anthropogenic hazards and disasters such as Tropical cyclones (prediction, precaution and mitigation), Marine/ tectonic hazard: Tsunami (prediction, precaution and mitigation) Hydrological hazards: Flash floods in Himalayan region and floods in southern part of West Bengal will be discussed. It discusses the sources, impacts and mitigation measures of nuclear hazard, radio-active contamination, CFC, plastic hazard, lead, arsenic and fluoride contaminations

2.5 FEEDBACK OF LEARNING ACTIVITIES

Preparation of poster and charts related to distribution of hazards and disasters.

2.6 EXAMPLES AND ILLUSTRATIONS

UNIT-9: CONCEPT AND TYPES OF HAZARDS AND DISASTERS

Introduction

To clearly understand the essential dimensions of hazards and disasters, it is necessary to introduce basic concepts regarding these extreme events. This chapter is, therefore, devoted to providing both traditional and contemporary definitions of hazards as well as disasters. The outcomes of such events arise in large part from human conditions and processes that differentially exposed or protect people and either limit or enhance their ability to appropriately respond to and recover from hazardous events or conditions.

Since both hazards and disasters are related to many disciplines and professional communities, there are many definitions of these two terms. An attempt will be made to provide definitions from an interdisciplinary perspective, which will help in arriving at a suitable definition of a term accepted by all dealing with extreme events. In most instances, the terms hazards and disasters, as used in this book, refer to natural hazards or disasters. In defining these two terms, a distinction will be made between them because people often use these terms interchangeably. In the hazard literature, however, each term has a precise and distinct meaning.

Subsequent to this discussion of definitions, an overview of hazard typologies will then be presented, followed by a discussion of important physical dimensions of natural hazards. Although three important components (definitions and distinctions of hazards and disasters, types of hazards, and physical dimensions of natural hazards) of extreme events are considered in this chapter, emphasis has been given to definitions and distinctions between hazards and disasters. Topics included in this introductory chapter will aid in understanding material presented in subsequent chapters.

Hazards and disasters: definitions and distinctions

Hazards

There are many definitions of hazards, but only one definition makes a distinction between hazards and disasters. According to Alexander (2000, p. 7), “a hazard is an extreme geophysical event that is capable of causing a disaster.” The word “extreme” is used here to signify a substantial departure (either in the positive or the negative direction) from a mean or a trend. Although Alexander did not specify the distinction between these two terms in his definition, it does suggest that hazards may transform into disasters and thus become sequential events. That is, every disaster starts with a hazard (Thywissen, 2006). Alexander’s definition, however, ignores the fact that human actions often play a major role in causing and/or exacerbating the effects of extreme events. Hazards represent the potential occurrence of extreme natural events, or likelihood to cause the severe adverse effects, while disasters result from actual hazard events (Tobin and Montz, 1997). Only after such an extreme event occurs may we term it a “natural disaster.” A hazard is a threat not the actual event. One of the earliest definitions of hazards is provided by Burton and Kates (1964) who maintain that natural

hazards are those elements of the physical environment that are harmful to humans and caused by forces extraneous to them. That is, these events originated in the physical environment and are not caused by humans, but have consequences harmful to them. Burton and Kates' definition is correct in the sense that hazards are harmful to people, but it fails to recognize people's role in causing or amplifying the impacts associated with hazards. For example, floods can originate either from a natural variability in meteorological conditions or from human actions, such as deforestation, intensive use of land, or failure of dams constructed to control flooding (Haque, 1997). Similarly, landslides are commonly triggered by heavy rainfall (some- times on hills and mountainsides previously denuded by wildfires), earthquakes, and volcanic eruptions, but also result from human activities such as logging, road building, and home construction, all of which can expose bare soil (Wisner *et al.*, 2004).

There is no doubt that humans affect natural processes in many ways and thus often contribute to hazards. Many physical aspects of natural hazards, however, are out of their control. This does not mean that people are just passive in facing hazards; they can and do construct defenses against and implement measures to mitigate the impacts of hazards. Still, many people, even in the United States, consider natural hazards to be "acts of God" or the result of some external force (Mitchell, 2000, 2003). A careful reading of digital and print media reports covering more recent events, including Cyclone Nargis in Myanmar (May 2, 2008), the outbreaks of tornadoes in the Midwest and Southeast United States (April 29 and early May, 2008, respectively), and the earthquake in China (May 12, 2008) all occurring within a time span of one month, found that these extreme events are typically characterized as acts of God or of Mother Nature that leave human victims in their wake. This perspective suggests – quite wrongly – that people have no role to play in creating/exacerbating disasters, nor in mitigating their impacts (Smith, 2001). This interpretation of natural hazards as acts of divine will or forces of Mother Nature exonerates people from sharing in the responsibility for the creation of such extreme events.

According to Cutter (1993), hazards are threats to people and the things they value (such as their homes and belongings and environment). Oliver (2001, p. 2) has provided a similar definition; to him "A hazard is a threat posed to people by the natural environment." In its broadest sense, a hazard reflects a potential threat to humans and their welfare. A hazard is defined by the United Nations as an agent or threat that is "A potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation" (UNISDR, 2004). This definition directly acknowledges the role of humans in causing/exacerbating hazards. It also makes the distinction between a hazard and a disaster by including the word "potentially," and it accounts for all possible hazard manifestations.

Hazards are also often defined in the context of vulnerability, which is a complex outcome of many factors, such as affluence, education, gender, demography, technology, and, above all, preparedness.

Location can also act as a vulnerability factor. African Americans living in New Orleans were the most vulnerable segment of the population impacted by Hurricane Katrina in 2005, not only because they were poor but also because they inhabited (almost exclusively) areas below sea level. Low-

income residents simply could not afford housing in areas above sea level. Another example of location as an important factor of vulnerability can be cited from Rio de Janeiro, Brazil. Many of the poor in this city occupy steep hillside locations above the reach of sewer, water, and power lines. Frequent heavy rains saturate the hillside and cause mudslides that destroy their rudimentary shelters. A combination of different factors, such as socio-economic conditions, geographic locations, political influences, and demographic characteristics, shapes the differing levels of vulnerability of different groups of people when an extreme natural event occurs (Wisner *et al.*, 2004).

Chapman (1999, p. 3) argues,

A natural hazard should be defined as the interaction between a human community with a certain level of vulnerability and an extreme natural phenomenon, which may be geophysical, atmospheric, or biological in origin, resulting in major human hardship with significant material damage to infrastructure and/or loss of life or disease.

He further claims that a particular level or severity of a natural event becomes a hazard only in relation to the capacity of society or individuals to cope with the impacts of such events. In addition to incorporating an ability to cope with the

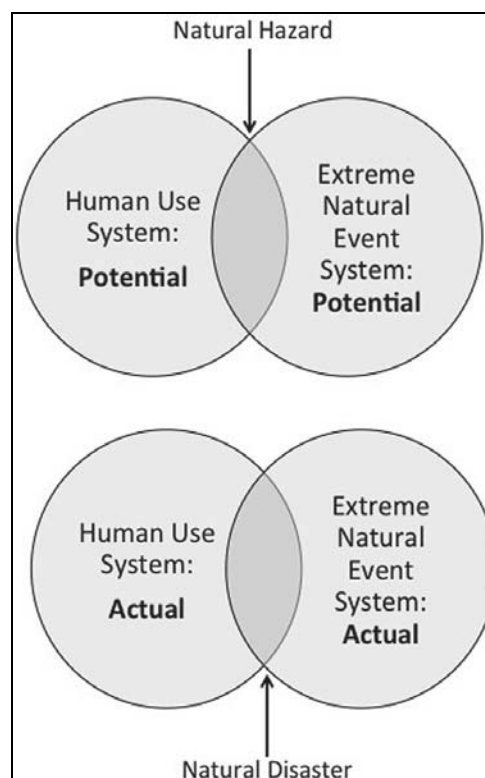


Figure 1.1 Distinction between natural hazards and natural disasters. *Source:* Modified after Erickson (n.d.).impacts of hazards, this definition also suggests further classification of hazards based on their source or origin.

Strategies adopted to cope with hazards can be classified in two different ways: by making a distinction between indigenous and modern coping mechanisms, as well as between those strategies adopted purposefully and those which are incidental. Planting floating rice, which grows with the rise of flood water in lowland areas of rural Bangladesh, is an example of an indigenous coping strategy, while the flood warning system introduced in the early 1990s by the government in this South Asian nation can be considered a modern coping strategy. Further, coping adaptations can be separated into those that are purposefully undertaken and those resulting from incidental actions. Cultivating different rice crops in different elevation zones within the floodplain of Bangladesh is an example of a purposefully undertaken coping strategy, while constructing houses in the floodplain using materials such as thatch and bamboo, which can be readily moved by boats to safer places during abnormal flooding, is an example of incidental action. Since the 1970s, hazards have been increasingly viewed as acts of human agency as well as the potential interaction or conflict between humans and one or more extreme natural events. Natural hazards lie at the interface between the (potential) natural event system and the (potential) human use system (Figure 1.1). Hazards thus exist within social, political, historical, and environmental contexts (Cutter, 2001). Hewitt (1983) and other researchers believe that hazards result more from social than geophysical processes. They eloquently argue that a “natural” hazard is a misleading term, as very little is natural about phenomena in which the danger results largely from human decision-making, land use, and/or socio-economic activities. Traditional explanations tend to emphasize hazards as processes of nature, their wrath inflicted randomly on unfortunate people. Contemporary hazard researchers blame many of the impacts associated with hazards on society and its varied institutions.

Hazards exist because humans and/or their activities are usually exposed to natural forces. As noted, we often create/exacerbate hazards, or modify hazard effects. For example, many wildfires are started by humans, either deliberately or unintentionally (Chapman, 1999). Hazards are in part socially constructed by individual perceptions and experiences. Thus, hazards can vary by culture, gender, age, race, socio-economic status, and political structure as well. For example, although the West Nile virus is usually fatal to the elderly, it is not to young adults, who often survive it. Normal flooding, which may inundate up to one-third of the total land area of Bangladesh, is seen by people of this country as a necessary and expected part of life; however, in the United States or most other Western countries, floods are generally seen as hazards.

The above example makes an important distinction between hazards and resources and supports the human ecology perspective of natural hazards proposed by Burton *et al.* (1978). They noted that when a natural event exceeds a threshold point or upper limit, a resource turns into a hazard. In the context of flooding in Bangladesh, 33% of the total land area of the country under water would be considered a threshold point. The specification of a threshold level for a given place or society, however, poses significant problems for hazard researchers. A threshold level for crippling snowfall in Toronto, for example, is much higher than the threshold for Norfolk, Virginia. Similarly, a temperature of 20°C is considered “freezing” in Tonga, but “scorching” in Baffin Island, Canada.

Any discussion of hazards must cover several essential attributes of such events. First, extreme natural events that do not affect (harm) people do not constitute a hazard. An earthquake in an uninhabited

desert area, for example, cannot be considered a hazard, no matter how strong its intensity or how long its duration. Second, what is considered a hazard in one society may not be considered as such in another. It will be evident from the excerpt (below) from the poem “Floods in Bulozzi,” by O.K. Sibetta [translated by Charles and Slater (1995)], that floods are not considered hazards in Zambia, but they are in Western countries. Third, a hazard to some is to others a business opportunity or even a joyful experience. Drought is a hazard to farmers, but not to those engaged in construction – they can build houses and repair roads without interruption. Similarly, global climate change is likely to benefit some regions of the world while detrimentally impacting others.

To say that a hazard to some may be a completely different experience for another is a subjective position. Whether or not one perceives driving without a seatbelt as hazardous, it can result in fatalities; whether or not one perceives smoking as a hazard, countless studies show that health is negatively affected by smoking (Mitchell and Cutter, 1997). However, a final attribute is that natural hazards constitute a threat to all societies, and these societies must cope with the hazards they encounter in one way or another. The type of hazards may vary from place to place, but no area is free from extreme natural events. Californians, for example, may not experience hurricanes, but they are vulnerable to earthquakes, mudslides, and wildfires.

In defining hazards, some researchers (e.g., Cutter, 2001; Cutter *et al.*, 2000) advocate inclusion of a technological dimension. They consider hazards on continuum of potential interactions among physical, social, and technological systems (Montz *et al.*, 2003). According to them, this dimension is important because technology may affect the extent of damage – particularly the number of deaths. A tropical cyclone in Bangladesh killed more than 500 000 people in November 1970, while Hurricane Agnes along the east coast of the United States caused the deaths of only 12 people in June 1972. Bangladesh introduced a cyclone warning system after the 1970 cyclone. For this reason, not a single person was evacuated from coastal areas prior to the landfall of the 1970 cyclone. In contrast, prior to the landfall of Hurricane Agnes, 250 000 people were evacuated and this evacuation undoubtedly saved many lives.

Another example in support of the effect of technology on hazard impact is the comparison between the 1998 Armenian earthquake and the 1989 Loma Prieta earthquake in California. Despite being of similar magnitude – the Armenian earthquake measured 6.9 on the Richter scale, while the California quake exceeded 6.9 – these two events caused very different numbers of deaths. At least 24 000 people died in Armenia, while the Californian quake killed only 63 people. The difference is often explained in terms of the different levels of technology in Armenia and the United States.

It is important to note that hazards are also a consequence of development and industrialization, which are directly associated with technology. In Europe, experts believe that countries such as France and Germany are more adversely affected by floods today because major rivers, such as the Rhine, have been straightened to ease commercial traffic. Interference with the natural flow of river water is thought to increase flood frequency in these countries.

Disasters

The term “disaster” is multifaceted, and many divergent definitions of the term appear in hazards literature (Mesjasz, 2011; Thywissen, 2006). There is extensive debate on the definition of disaster. At least two edited volumes are dedicated solely to this task (Quarantelli, 1998; Perry and Quarantelli, 2004). Fundamentally, disasters are actual threats to humans and their welfare. Disasters are generally conceived as adverse events, the negative impacts of which cannot be overcome without outside assistance, or support from many outside sources, including state and national governments, and even governments from other countries. One of the earliest definitions of disaster is provided by Charles Fritz. He defined a disaster as:

an event, concentrated in time and space, in which a society, or a relatively self-sufficient subdivision of a society, undergoes severe danger and incurs such losses to its members and physical appurtenances that the social structure is disrupted and the fulfilment of all or some of the essential functions of the society is prevented. (Fritz, 1961, p. 655)

According to Degg (1992), natural disasters result from spatial interaction between a hazardous environmental process (i.e., an extreme physical phenomenon such as an earthquake) and a population that is sensitive to that process and likely to experience human and/or economic loss from it. Disasters disrupt “normal” life, affect livelihood systems, and halt individual and/or community functions at least temporarily. Disasters often erase decades of development in a matter of minutes and push an affected community and/or nation years back in its quest for development. For example, the 2004 Indian Ocean tsunami caused a 20-year setback in the development of Maldives, an island nation off the coast of India (Coppola, 2007). Burton and Kates (1964) consider disasters as abrupt shocks to the socio-economic and environmental system (see also Turner, 1976).

To Cohen and Werker (2004, p. 3), “shock” refers to the natural phenomenon itself – the volcanic eruption, earthquake, drought, etc. – and “disaster” refers to the net impact of the shock on a population, when there is sufficient suffering. Thus, whether or not a shock translates into a disaster depends on the nature of emergency response, and on the mitigation measures and the level of preparedness (public and private) prior to an extreme natural event. For example, the extent to which a drought actually causes famine depends, to a great degree, on the ability of the government to bring adequate food from other areas. As a result, “natural” disasters are never 100% natural. In conflict zones, extreme events are even less “natural” because governments in such areas allow or encourage disasters in order to inflict suffering on their enemies (Cohen and Werker, 2004). Though earthquakes, typhoons, and tsunamis may be “acts of God,” their impacts on a population are certainly nonrandom. For other disasters, such as floods and droughts, humans often contribute to their occurrence by draining wetlands, clearing forest, and using intensive farm practices, especially on marginally arable land. By choosing an optimal level of disaster prevention and mitigation, including preparedness and emergency response, governments are able to lessen the human impact of natural disasters.

Disasters are often defined as large-scale, stressful and traumatic events (Briere and Elliott, 2000; Dominici *et al.*, 2005). Disasters cause widespread destruction of property, infrastructure, and natural resources and are responsible for a substantial number of deaths and injuries. As a result, a disaster is usually defined as an event that leaves a large and tragic impact on society, which disrupts established ways of life, interrupts socio-economic, cultural, and sometimes political conditions, and slows the pace of development in the affected communities. Unfortunately, it is not easy to define a *large* impact. There are no agreed-upon boundaries to determine exactly when a threshold has been reached such that one can categorically say, “This constitutes a disaster.” However, hazard researchers have made attempts to quantify disaster impacts in terms of the number of deaths, injuries, or the extent of damage experienced. For example, Sheehan and Hewitt (1969) defined disasters as events leading to at least 100 deaths, 100 injuries, or US\$1 million in damages. Glickman *et al.* (1992) used 25 deaths as their threshold to consider an event a disaster.

Researchers at Resources For the Future (RFF) in Washington, D.C. have compiled a database of events that occurred between 1945 and 1986, including both natural and industrial disasters. This database excludes drought, and industrial accidents are limited to those in which a hazardous material caught fire, exploded, or was released in a toxic cloud. The recording threshold was set at a minimum of 25 fatalities for natural disasters, compared with 5 for industrial disasters (Smith, 2001). Use of differential weights was justified on the grounds that the public perceives industrial hazards/accidents more severely than the death toll alone would suggest.

The Center for Research on the Epidemiology of Disasters (CRED) at the Catholic University of Louvain in Brussels, Belgium, has developed the Emergency Events Database (EM-DAT), starting in 1988. EM-DAT organizes and counts disaster events by country. Thus disasters affecting many nations generate multiple registrations. It is the goal of EM-DAT to systematically define and routinely report disasters in a timely manner with high fidelity and consistency worldwide. However, CRED defines a natural disaster as “a situation or event which overwhelms local capacity, necessitating a request to the national and international level for external assistance, or is recognized as such by a multilateral agency or by at least two sources, such as national, regional, or international assistance groups and the media” (Guha-Sapir *et al.*, 2004, p. 16). By placing the event within the context of “local capacity,” this definition indirectly encompasses the notion of scale, since local capacity can refer to places and populations of varying size. This is a very useful definition since some disasters occur in small towns and impact only a small number of people.

In order for a disaster to be entered into CRED’s database, at least one of the following criteria has to be fulfilled (Smith, 1996): 10 or more reported killed by the extreme event; at least 100 people reportedly affected; a call for international assistance; or the declaration of a state of emergency. Among these four criteria, any appeal for international assistance from the country concerned usually takes precedence over all other criteria (Smith, 1996). These criteria do not include, however, the number of people injured or the monetary value of any property damage.

It is important to note that people are considered to be affected by an extreme natural event if they require immediate assistance (during the period of emergency) to fill basic survival needs, such as food, water, shelter, sanitation, and immediate medical attention (Picture This, 2003). Donor countries and aid agencies use the number of people affected by a disaster to decide whether they will provide emergency assistance to victims of these extreme events. For this reason, governments of disaster-impacted countries, hoping to receive external aid, often deliberately exaggerate this figure.

There are, however, several problems with the criteria used by CRED to enter a disaster in its database. First, 10 fatalities is a fairly low figure for some societies. The deaths of 10 people would constitute a relatively significant figure for more developed nations such as the United States, but in lesser developed societies many more people tend to be killed by disasters. Another problem is with the declaration of a state of emergency. In the United States, people will not receive any funding from public sources until the state and federal governments declare a state of emergency. This declaration is often politically motivated and not necessarily based on need (Schmidtlein *et al.*, 2008). For example, if it is close to election time, it may be relatively easier for an affected area to be declared a disaster than would otherwise be the case. As mentioned, another problem is that CRED criteria do not take into consideration monetary losses or the number of people injured.

CRED data can, however, be used to identify what they term “significant” natural disasters, for which the more stringent criteria are: (1) number of deaths per event – 100 or more; (2) significant damage – 1% or more of the total annual national gross domestic product (GDP); and (3) affected people – 1% or more of the total national population (Hewitt, 1997; Smith, 2001). While the first criterion uses an absolute measure, the last two criteria represent relative measures. For this reason, relative criteria adopted for “significant” natural disasters can be used easily for comparative purposes across countries with disasters so labeled. The CRED database is now regarded as the primary reference among hazard researchers because it is more comprehensive than the others and also because it is used by disaster agencies themselves.

The United States Office of Foreign Disaster Assistance (OFDA) has maintained a record of disasters affecting all overseas countries since 1900. This organization relies heavily on officially declared disasters – those in which the Chief of the US Diplomatic Mission in the affected country decides that a US government response is required (Smith, 1996). Even within the United States, disaster victims are not eligible for federal emergency assistance if the president does not declare an area disaster-affected. According to the Disaster and Emergency Assistance Act, governors of affected states may request that the president issue a declaration indicating that an emergency or a major disaster exists.

A request for presidential disaster declaration is based on the finding that the disaster is of such severity and magnitude that effective response is beyond the capabilities of the affected state and local

governments, and that federal assistance is necessary (GAO, 1995). Once a declaration is issued by the president, different types of assistance are available to disaster victims, including temporary housing, public assistance program funds for the repair of public facilities, public assistance grants for such activities as debris removal, and loans and grants to restore homes and businesses.

As indicated, while hazards have traditionally been represented as the work of natural forces, recent research indicates that society plays an important part in determining which natural events become disastrous. Thus, natural disasters are widely considered the outcome of an interaction between the natural events system (geophysical processes) and the human use system (socio-economic, cultural, and physical conditions). This, as mentioned previously, means that not all natural disasters are exclusively natural (Tobin and Montz, 1997). For this reason, many hazards researchers prefer using the term “environmental” disaster rather than “natural” disaster (Oliver, 2001). Others stress that while hazards are natural, disasters are not. Natural events may become disasters if they occur in vulnerable human environments (Wisner *et al.*, 2004).

Similar to Mauro (2004) and Wisner *et al.* (2004), El-Masri and Tipple (1997) consider that natural disasters occur because of the interaction between natural hazards and humans living in vulnerable conditions that can arise from socio- economic, cultural, and/or political conditions and are usually created by human action. This implies that impacts of disasters are not uniform across society. As previously indicated, natural disasters are complex events with multidimensional outcomes: socio-economic, cultural, demographic, political, physical, and humanitarian. The interrelated and complicated nature of natural disasters renders any manageable definition of the term contentious and difficult. However, the United Nations Center for Human Settlements (UNCHS) provides a holistic framework for natural disasters, in terms of creation, effects, outcomes, and responses:

natural disaster could be defined as the interaction between a natural hazard, generated in most cases from a sudden and unexpected natural event, and vulnerable conditions which cause severe losses to man and his environment (built and natural). These losses create suffering and chaos in the normal patterns of life, which lead to socio-economic, cultural, and sometimes, political disruption. Such a situation requires outside intervention at international and national levels in addition to individual and communal responses. (UNCHS, 1994)

Outside intervention is also evident in many other definitions of disaster. Porfiriev (1996) defines a disaster as a breaking of the routines of social life in such a way that extraordinary measures are needed for survival. Spiegel (2005, p. 1915) defines a disaster as “a serious event that causes an ecological breakdown in the relationship between humans and their environment on a scale that requires extraordinary efforts to allow the community to cope, and often requires outside help or international aid.”

Wisner *et al.* (2004, p. 50) claim that a “disaster occurs when a significant number of vulnerable people experience a hazard and suffer damage and/or disruption of their livelihood system in such a

way that recovery is unlikely without external aid.” They also note the need for outside intervention in the form of emergency relief to cope with the impacts of disaster at household levels in their access model. This model “deals with the amount of ‘access’ that people have to the capabilities, assets and livelihood opportunities that will enable them (or not) to reduce their vulnerability and avoid disaster” (Wisner *et al.*, 2004, p. 88). As access to resources is essential to maintain livelihoods, less access means an increased level of vulnerability. Thus, a disaster results from the combination of hazards, conditions of vulnerability and insufficient capacity to reduce the potential negative consequences of risk. Quarantelli (1985), on the other hand, provides a definition of disaster in the context of demand and capabilities of a community to handle an extreme event. He defines a disaster as a crisis occasion where demands exceed capabilities, and he offers the following continuum of labels for disasters of varying magnitude relative to community resources (Quarantelli, 2006):

Crisis: Capacity exceeds demand – with capacity to spare
Emergency: Capacity meets or somewhat exceeds demands
Disaster: Demand exceeds capacity
Catastrophe: Demands overwhelmed and may destroy capacity.

Similar to Quarantelli (1985), Gad-el-Hak (2010) recently classified disasters into five groups. His classification is based on one of the two criteria: either number of person deaths/injuries/displaced/affected or the size of the affected area of the event.

Although there is a lack of consensus on a definition for a natural disaster, two important points emerge from the previous discussion. First, extreme natural events invariably cause extensive damage, which is usually expressed in monetary terms. In calculating damage, only direct material damage is included and valuation of costs of human life is rarely considered. Extreme events may or may not lead to deaths, but they usually impose a severe economic burden on the victims and communities of both developed and developing countries. This is particularly true for developing countries where disasters create demands that typically exceed resources available at the household and/or community levels (Wenger, 1978).

Inherently, disasters necessitate more than just a localized response in order for a community to survive and recover. This means that not all adverse events are disasters but rather only those that overwhelm the response capability of the affected community. For example, a simple house fire requires response by a jurisdictional fire department. This fire may cause property damage, death, and injury. However, as house fires are routine occurrences that are easily managed locally, they are not considered disasters, but wild forest fires are (Coppola, 2007).

It follows from the above that disaster-impacted communities require the assistance of outside donors of all types, including governments, non-government organizations (NGOs), and private donors. Not only do disaster victims need outside support to help cope with losses, hardships, and distress, but many of the impacts of natural disasters are also influenced by the effectiveness of relief and emergency operations.

As indicated, the extent of damage and disruption caused by extreme natural events can be minimized by adopting hazard mitigation and preparedness measures at various levels before events occur. People do not have to be merely reactive when coping with disasters; they can adopt measures to reduce disaster risk and/or losses. From subsequent events, such protective measures seek to improve the household, community, and government's abilities to absorb the impact of a disaster with a minimum amount of damage. Mitigation measures include land-use regulations, building codes, and construction practices designed to ensure that structures are able to resist or withstand the physical forces generated by hazards, such as wind or seismic forces (Tierney *et al.*, 2001).

Preparedness relates to individual and/or community readiness to take pre- cautionary measures in response to threats posed by an impending disaster. Preparedness activities may include devising disaster plans, gathering emergency supplies, training response teams, and educating residents and others about disaster vulnerability and what to do to reduce it (Mileti, 1999). For example, in the case of an impending hurricane, preparedness activities include, among other things, buying bottled water and/or placing shutters on windows.

In the post-disaster period, victims generally adjust to losses by bearing and spreading losses among various organizations and individuals (White, 1974; White and Haas, 1975; Burton *et al.*, 1978; Hewitt, 1997; Chapman, 1999; Smith, 2001). Although disaster victims all over the world absorb the major share of losses, they expect, and usually receive, outside support in mitigating disaster losses. This support usually comes as emergency or disaster aid. Thus, the outcome is determined not only by the severity of the disaster but also by the overall response, timeliness, and adequacy of any emergency relief received. However, hazard researchers differ in their opinions over whether disasters should even be addressed by relief measures (Susman *et al.*, 1983; Hewitt, 1997; Bolin and Stanford, 1999; Wisner *et al.*, 2004).

There are several problems with the definitions of disasters provided here. As noted, in the context of fatalities caused by disasters, several definitions use a threshold number, which may be interpreted differently in different societies, cultures, or countries. Secondly, most of the definitions presented ignore the concept of a scale factor, or an "impact ratio," which simply means that disaster that causes harm to 100 persons signifies a very different level of impact for a community of 500 versus a community of 50 000 (Norris *et al.*, 2002a, 2002b). Similarly, these definitions also ignore the fact that US\$1 million in disaster damage will affect developed and developing countries differently. In addition, events of identical type and equal magnitude may pose very different challenges for populations of different sizes or for communities with ample versus limited response capacity (UNDP, 2004).

Even when disasters are defined in the context of property damage, in many instances such definitions ignore inflation. Moreover, disaster definitions do not consider that damage and death/injury data may be unreliable, depending on the country/entity reporting them; such data are not reliable for most developing countries – often, as mentioned, these figures are inflated to receive international aid.

Further complicating the issue is the fact that many natural disasters arise from a combination of individual geophysical events. For example, on April 2, 2007 at 7:39 ^{AM} local time, a magnitude 8.1 earthquake hit the Solomon Islands' Western Province. The earthquake triggered over 1000 landslides, and generated a sizable tsunami. The tsunami was responsible for 50 reported deaths (McAdoo *et al.*, 2009). McAdoo *et al.* (2009) reported that of all fatal earthquakes occurring during the past 40 years in this island, 21.5% had deaths due to secondary (non-shaking) causes. Thus, it may be difficult to allocate all fatalities or losses to a single event. Finally, little or no attempt has been made in these definitions to assess or even acknowledge more indirect losses, such as those resulting from injury, loss of employment, or forced relocation after a disaster.

Wisner and his colleagues (2004) classified available definitions of extreme events into three broad groups: those that emphasize the trigger role of geotectonics, climate or biological factors arising in nature; definitions that focus on the human response, psychological and physical trauma, economic, legal and political consequences; and a final group that does not deny the importance of extreme events as triggers, but puts the main emphasis on the various ways in which social systems operate to generate/exacerbate disasters by making people vulnerable. The first two groups assume that disasters are departures from "normal" social functioning and that recovery means a return to normal. Definitions from all three of these classes have been included in this section.

Types of hazards

Hazards arise from numerous sources. In order to establish some order in an ever-increasing list of hazards, many efforts have been made to develop typologies of hazards. Classification of hazards provides a useful framework for identifying similarities among and making generalizations about hazardous events. Typologies also promote sound management practices. Most of the existing hazard typologies use the causes or origins of hazard events as the classifying principle.

Most hazards, however, arise from interrelated causes and the allocation of a hazard to one class is often difficult. For this reason most researchers now refrain from proposing a single cause-based typology of hazards. Still, it is possible to classify hazards according to the area in which they usually originate (Mitchell and Cutter, 1997).

Natural hazards

Natural events, those originating from extreme and/or common physical processes, are referred to as natural hazards. Earthquakes, volcanic eruptions, floods, hurricanes, tsunamis, blizzards, and tornadoes that originate in the lithosphere, hydrosphere, or atmosphere are some examples of natural hazards. Natural hazards can be further categorized into hydro-meteorological or atmospheric hazards (typically weather-related) such as floods, droughts, forest fires, and tornadoes, and geophysical or geologic hazards such as earthquakes, tsunamis, and volcanic eruptions.

Based on the nature of the physical processes involved, Tobin and Montz (1997) classified natural hazards into four categories: (1) meteorological (tropical cyclones/hurricanes, thunderstorms, tornadoes, lightning, hailstorms, wind- storms, ice storms, snowstorms, blizzards, cold waves, heat waves, avalanches, fog, and frost), (2) geological (earthquakes, volcanoes, tsunamis, landslides, subsidence, mudflows, and sinkholes), (3) hydrological (floods, droughts, and wild- fires), and (4) extraterrestrial (meteorites). Natural hazards originating from different (and even similar) physical processes may have few or no similarities. For example, avalanches typically have little in common with earthquakes or tornadoes, and volcanic eruptions and tropical cyclones would seem to be completely dissimilar.

Natural hazards often vary regionally, even seasonally, and they also frequently trigger secondary hazards. For example, landslides, tsunamis, and fire may follow earthquakes. Thunderstorms may be accompanied by heavy rains that can cause mudflows, flash floods, and conventional flooding. The volcanic eruption of Mt. St. Helens in 1980 led to an earthquake, landslides, floods, and wildfires. Table 1.3 lists selected secondary hazards and their causing extreme natural events. Note that depending on time of initiation, a hazard can be a primary or a secondary hazard.

Closely related to secondary hazards are compound disasters, which can occur either sequentially or simultaneously with one or more disasters. Compound disasters have a tendency to exacerbate consequences and increase victims' sufferings. However, natural hazards also arise from rather common natural events, such as hail, coastal erosion, and heat waves – all of which can cause considerable damage to the natural environment and society. As indicated, the focus of this text is on natural hazards and disasters.

Social hazards

Some hazards, such as famine, warfare, acts of terrorism and civil disorders originate in social systems. These types of hazards are also termed “intentional hazards” as these are caused or exacerbated by human action. Contrary to popular belief, famine is a social hazard because it is not necessarily caused by drought. In analyzing the Great Bengal famine of 1943 on the basis of his “entitlement approach,” Sen (1981) concludes that the famine was not caused by drought, but rather by the government’s inability to take proper action against the massive hoarding of food grains by corrupt politicians and their associates, whose primary aim was to gain wealth through inflated prices. Sen (1981) concluded that famine is dependent on the pattern of individual legal entitlement to acquire enough food to avoid starvation. He further claims that famine is not entirely caused by drought; a weak and insufficient political system may also create such an outcome.

Some social hazards, such as acts of terrorism, are created with the sole intention of provoking widespread fear that often extends beyond those directly targeted (Butler *et al.*, 2003). Civilians, rather than military forces, are increasingly targeted and represent a growing proportion of the casualties, from all types of mass violence, including acts of terrorism. Government policy can also cause social hazards, such as religious and ethnic strife.

Certain social hazards, such as civil or armed conflicts, are often termed “complex emergencies,” also known as complex humanitarian emergencies (CHEs) (Spiegel, 2005). The IASC (Inter-Agency Standing Committee) defines a CHE as a “humanitarian crisis in a country or region where there is a total or considerable breakdown of authority resulting from the internal and/or external conflict and which requires an international response that goes beyond the mandate or capacity of any single agency” (IASC, 1994). These create large number of refugees and internally displaced persons (IDPs). Of all the types of disaster response, none is more difficult and involved than that directed at treating and ending a CHE.

There are more similarities than differences between complex emergencies and natural hazards. Both often have increased mortality, morbidity, and displacement. Victims of both events need external aid as well as immediate assistance, such as water, food, shelter, health care, and protection. Sexual exploitation and violence against women and children may occur in varying degrees following both types of events. Furthermore, complex emergencies and natural hazards can occur concurrently. As noted, the 2004 Indian Ocean Tsunami (IOC) affected areas in Sri Lanka and Aceh Province, Indonesia that had existing rebel insurgencies. Aceh is subject to a 30-year-long violent conflict between the Free Aceh Movement (GAM) and the national government.

Between complex emergencies and natural hazards (or disasters), both public and private response is quicker and overwhelming in the case of hazards that become disasters. These events also typically receive more media attention than complex emergencies, because natural disasters can occur suddenly anywhere in the world, and their causes cannot easily be attributed to people. Complex emergencies are more political and complicated; depending on one’s perspective, there is always someone or some group to hold accountable. Thus, it is often difficult for foreign and multinational agencies to remain neutral. Furthermore, providing aid in a complex emergency can sometimes exacerbate the situation or tensions among polarized groups (Spiegel, 2005).

Biological hazards

Hazards that originate for biological reasons (e.g., epidemics) are called biological hazards or biohazards. Sources of biological hazards include bacteria, viruses, medical wastes, insects, plants, birds, animals, and humans. These sources can cause a variety of health effects ranging from skin irritation, allergies, and infections (e.g., AIDS and tuberculosis) to deaths. The United States Centers for Disease Control and Prevention (CDC) categorizes various diseases in levels of biohazard – Level 1 being minimum risk and Level 4 being extreme risk.

Biological hazards are often divided into two categories: pathogens and toxins (McEntire, 2007). Pathogens are organisms that spread disease and may include anthrax, smallpox, influenza, plague, hemorrhagic fever, and rickettsiae, while toxins are poisons created by plants and animals. While pathogens could kill many people, toxins are not likely to do so. For example, the 1918 Spanish influenza pandemic killed more people in the United States than had died in combat in World War I

(McEntire, 2007). In recent years, public health officials have been very much concerned with several diseases (e.g., foot-and-mouth disease, HIV/AIDS, the hantaviruses, severe acute respiratory syndrome (SARS), the West Nile virus, and the Avian “bird” flu) associated with biological hazards.

Technological hazards

Technological hazards originate from the interaction of society, technology, and natural systems (e.g., explosions, releases of toxic materials, and oil spills) and constitute a relatively new kind of threat. Events of this group are also termed (anthropogenic) non-intentional hazards, based on the absence of purposeful human causation. Terrorism, including bioterrorism, is an example of anthropogenic hazard of intentional origin. This topic will be covered in Chapter 2. However, industrial and transportation-related accidents and progressive or precipitous destruction of ecosystems reflect failures or side-effects of human-devised technologies, failures of judgment, or even flagrant human neglect. Serious consequences associated with technological hazards are largely the result of site-specific accidents, rather than a low-dose exposure of the general public to certain toxic substances.

Early concern about technological hazards was confined to developed countries, but the risks have now extended to developing countries through industrialization (Smith, 2001). Several particularly devastating technological disasters include the accidental toxic gas release from a Union Carbide pesticides plant in Bhopal, India in 1984, and the nuclear power plant accident in Chernobyl, Russia in 1986. The Bhopal disaster is frequently cited as one of the world’s worst industrial disasters; it killed almost 3000 people. Another 300 000 were affected by exposure to the deadly gas, and perhaps 150 000 of those suffered long-term permanent disabilities, including blindness, sterility, kidney and liver infections, and brain damage (Fellmann *et al.*, 2008).

McEntire (2007) divided technological hazards into five categories: industrial hazards, structural collapse hazards, nuclear hazards, computer hazards, and transportation hazards. Industrial hazards are hazard agents produced by the extraction, creation, distribution, storage, use, and dispersal of chemicals, such as chlorine, benzene, insecticides, and fuel. Structural hazards occur when buildings, roads, and other construction projects collapse due to poor engineering. A nuclear hazard results from the presence of radioactive material, while computer hazards are disruptive hazards associated with computer hardware and software. Transportation hazards occur on roads, railways, air, or water bodies. Such hazards may result from adverse weather conditions, human error, and/or mechanical failure.

Chronic hazards

These hazards arise from long-term events such as continuous discharges and occupational exposure. Chronic hazards do not stem from one event, but arise from continual or long-term conditions or problems (e.g., famine, resource degradation, and pollution). These hazards, also termed ‘elusive’

hazards, can lead to health or environmental effects that occur gradually over a long period of time following continuous and repeated exposure to relatively low levels or concentrations of a hazardous agent. Chronic hazards are the type that will be most affected by changes in the global environment. Unlike natural hazards, their effects are generally less concentrated in time and space. For example, industrial pollution rarely poses an immediate threat to human life on a community scale. Technological and chronic hazards may be called human-induced hazards.

There are many other hazard classifications based on origin. Chapman (1999), for example, classified hazards into three broad categories: hazards originating primarily from the atmosphere and hydrosphere (e.g., tropical cyclones, tornadoes, blizzards, and droughts), hazards originating primarily from the litho- sphere (e.g., earthquakes, volcanic eruptions, and tsunamis) and hazards originating primarily from the biosphere (e.g., wildfire, bacterial, and protozoan hazards). Another origin-based classification is as follows: endogenous origin (e.g., earthquakes and volcanic eruptions), exogenous origin (e.g., floods and droughts) and anthropogenous origin (e.g., flood caused by dam failure). In a similar vein, the World Health Organization (1999) offered the following five-fold typology:

Natural-physical: hydro-metrological and geophysical Natural biotic, biological: pest infestations, epidemics, pandemics. Socio or pseudo natural: human transformation of the natural environment Man-made technological: contamination, explosions, conflagrations. Social: conflict including war, civil strife, violence. In addition to origin-based classification, extreme events can also be grouped using other criteria. Some attempt has been made to scale the range of hazards and disasters according to whether the impacts are intense and local (e.g., earth- quake and tornado) or diffuse and widespread (e.g., flood and drought) within society (Smith, 2001). Classification is also based on the extent to which extreme events are voluntary (e.g., civil strife and mountaineering) or involuntary (e.g., earthquake and tsunami). Disasters can also be divided into two major categories according to speed of occurrence: abrupt and slow onset. Earthquakes and tornadoes, for example, happen quickly, whereas drought and desertification occur over an extended period of time.

Noji (1997) uses a classification that distinguishes between natural disasters and human-generated disasters. His classification facilitates an understanding of the loose boundary that exists between these areas, as well as the potential for synergy. For example, an earthquake (natural disaster) may cause electrical fires and destruction of buildings (components generated by humans). A disaster that results from interaction between natural and human phenomena is referred to as NA-TECH, a portmanteau of “natural” and “technological” disaster types.

The EM-DAT of CRED distinguishes two generic categories for disasters: natural and technological. The former is divided into two groups:

Hydro-meteorological disasters: avalanches/landslides, droughts/famines, extreme temperatures, floods, forest/scrub fires, windstorms and other disasters, such as insect infestations and wave surges.

Geophysical disasters: earthquakes, tsunamis and volcanic eruptions.

The technological disasters comprise three groups:

- Industrial accidents: chemical spills, collapses of industrial infrastructure, explosions, fires, gas leaks, poisoning, and radiation.

Transport accidents: by air, rail, road or water means of transport.

Miscellaneous accidents: collapses of domestic/nonindustrial structures, explosions, and fires (IFRC and RCS, 2007).

A major shift in the classification of hazards and disasters has recently been noted by Montz and her colleagues (2003). They claim that instead of neatly dividing these events into natural and technological as was done a decade earlier, hazards and disasters are now viewed as a continuum of interactions among physical/environmental, social, and technological systems, ranging from extreme natural events to technological failure to social disruption to terrorism. This shift is also reflected in the hazards/disasters typologies presented above (Paul, 2011).

UNIT-10: ASSESSMENT OF RISK AND VULNERABILITY

Defining vulnerability

In context of vulnerability, it is necessary to understand why an individual, house- hold, group, or community may suffer more or less than another in the wake of a natural disaster (what economists call shock, or what ecologists and resilience re- searchers would consider a major disturbance to the system). Hazard researchers explain the level to which these may be affected in terms of vulnerability. The etymology of the word vulnerability indicates harm, as it means “wounds,” from the Latin *vulnerabilis* (Coppola, 2007). Merriam Webster’s Collegiate dictionary defines vulnerable as “capable of being physically wounded” or “open to attack or damage.” Vulnerability, then, is the state or condition of being capable of being wounded, attacked, or damaged. It is a measure of an entity’s inability to deal with natural disasters.

An examination of the literature penned on vulnerability reveals a wide range of definitions. In her progress report on vulnerability to environmental hazards, Cutter (1996) listed 18 different definitions of vulnerability in the hazard literature. Since the publication of Cutter’s 1996 paper many other definitions of vulnerability have emerged. For example, Thywissen provided 36 definitions in 2006 (Thywissen, 2006). Vulnerability definitions of only three hazard re- searchers are cited by both Cutter (1996) and Thywissen (2006). The existence of a large number of definitions reflects that vulnerability is a topic of interest to hazard scholars of many different disciplines, who have different ideological positions and different end purposes. As a result, none of the available definitions of vulnerability is accepted by all hazard researchers. In general, physical scientists and engineers have typically defined vulnerability in contexts of physical exposure to extreme events and adverse

outcomes, while social scientists have emphasized the role of social structures and differential access to economic, political, and psychological resources in making certain groups more disadvantaged in the face of disasters (Adger, 2006; Mustafa *et al.*, 2011). Some (e.g., Cutter, 1996; Cutter *et al.*, 2000) have attempted to bridge the gap between these two perspectives. Thus, a vast majority of definitions of vulnerability fall into at least one of these three categories: (1) focus on physical factors, (2) focus on social/human factors, and (3) a combination of physical and social/human factors.

A review of the plethora of definitions is not necessary here, but it will be helpful to begin with a few of them, at least. Blaikie and his colleagues (1994, p. 9), who are pioneers in vulnerability research, define vulnerability as “the characteristics of a person or group in terms of their capacity to anticipate, cope with, resist, and recover from the impact of a natural hazard.” Impacts include damage to private property, infrastructure, economic vitality, habitat, and productive ecosystem, as well as human death, injury, and illness. Blaikie and his colleagues take a rigorous approach to this term and choose to apply it only to people and not to the human-built environment. Cutter *et al.* (2003), on the other hand, maintain that the quality of the built environment influences human vulnerability. As one seismologist and disaster expert from Columbia University’s Earth Institute was quoted as saying, “Earthquakes don’t kill people. Bad buildings kill them” (Walsh, 2010).

Human vulnerability is inextricably tied to the level and quality of development of the human-built environment in any place. This environment includes the physical infrastructure necessary for human habitation and activities, such as homes, office buildings, schools, hotels, roads, railways, water and sewage lines, and energy transmission lines, as well as any modifications that people make to the natural environment, such as the removal of mountaintops, cutting of trees, and transformation of wetlands to grow crops or for residential use. While studying flood vulnerability, Brody *et al.* (2008) and Zahran *et al.* (2008) focused on the attributes of built environment and examined the influence of the total number of dams in a county, percentage of a county area covered by impervious surfaces, and extent of wetland alteration on vulnerability at the county level.

However, another definition of vulnerability incorporates the notion of systems: “vulnerability is the degree to which a system acts adversely to the occurrence of a hazardous event” and the capacity of the system to absorb and recover from the hazardous event (Timmerman, 1981). In a similar way, Sarewitz *et al.* (2003) state that vulnerability “describe[s] inherent characteristics of a system that create the potential for harm but [is] independent of the probabilistic risk of the occurrence (“event risk”) of any particular hazard or extreme event.” The risk factors in the Sarewitz *et al.* (2003) definition indicates there are elements of a disaster that lay beyond the control of humans in any regard; these are generally accepted as the physical characteristics of the event itself, not the vulnerability to any particular event. Liverman (1990) differentiates between vulnerability as defined by social, economic, and political conditions and vulnerability as a biophysical condition. Vulnerability, however, also extends to places, as Susan Cutter and her colleagues (2000) have theorized. Their work examines how the array of factors contributing to biophysical and social vulnerability together creates

place vulnerability. The most useful element of the concept of vulnerability is the idea that a disaster does not translate directly into risk, but rather is measured by the degree of Vulnerability of the individuals or system in relation to that disaster. The underlying factors causing vulnerability, thus, define risk. Therefore, vulnerability and risk cannot be considered the same. Risk is generally considered to be primarily just a physical factor, and does not take into account the social characteristics that can determine a population is more vulnerable to a hazard. This opens up the chance to use the term “vulnerability” to identify, classify, and level people (Lein, 2009). Seemingly, government agencies often use such definitions to attract and obtain funds from external sources (Wisner, 2003; Wisner *et al.*, 2004). This has encouraged a negative meaning of weak, passive people, unable to cope.

However, vulnerability is also defined in terms of three physical and socio-economic variables: exposure, sensitivity, and adaptive capacity. Exposure is the frequency of an event, which is considered as a physical factor. It is a risk measure directly related to proximity and the environmental characteristics at a particular place. Sensitivity is the magnitude of an event in relation to human response, which can be considered a combination of physical and socio-economic factors. It reflects the degree to which people and place can be harmed. Adaptive capacity is the ability of the people or a system to easily and quickly cope with the impact of a disaster. Adaptive capacity is considered to be primarily a socio- economic factor. All these factors are vital variables that determine the level of vulnerability of a given population or a place (Cutter, 1996; Adger, 2006; Polsky *et al.*, 2007).

The vulnerability of a person, a group, or a system is not simply a product of the intensity or magnitude of a disaster rather it evolves over a long period of time and involves a combination of physical as well as socio-economic, demographic, and other factors, including attributes of the built environment. In development literature, vulnerability covers a multitude of issues like food insecurity, market situation, production relations, and social and economic justice (Sen, 2002). Vulnerability is determined by social systems and power, not by natural forces. It needs to be understood in the context of social, economic, and political systems that operate at national and even international scales (Wisner *et al.*, 2004). The vulnerability perspective considers most natural disasters as unnatural. A concept that is useful in refining the concept of vulnerability is that of “resilience,” often characterized as the opposite of vulnerability (Coppola, 2007). Cardona (2004) maintains that vulnerability is related to physical and socio-economic fragility, susceptibility or lack of resilience of the exposed elements. He points out that population growth, rapid urbanization, environmental degradation, global warming, and war have all increased vulnerability.

Anthony Oliver-Smith (2004) argues that vulnerability is fundamentally a political ecological concept: “Vulnerability is the nexus that links the relationship that people have with their environment to social forces and institutions and the cultural values that sustain or contest them” (p. 10). According to Bolin and Stanford (1999), vulnerability concerns the complex of social, economic and political circumstances in which people’s lives are embedded and this factor structure the choices and

opinions they have in coping with environmental hazards. They claim that: “The most vulnerable are typically those with the fewest choices, those whose lives are constrained, for example, by discrimination, political powerlessness, physical disability, lack of education and employment, illness, the absence of legal rights, and other historically grounded practices of domination and marginalization” (Bolin and Stanford, 1999, pp. 9–10).

In their Pressure and Release (PAR) model, Blaikie and his colleagues (1994) and Wisner *et al.* (2004) posit that a disaster occurs because people are vulnerable – that for physical or economic or social reasons they are exposed and will suffer damaging losses if a hazard strikes. This vulnerability is the result of a set of unsafe conditions (e.g., being unable to afford safe housing, having to engage in dangerous livelihoods, and living in a location with high incidence of hazard events), which are then nested in explanatory fashion within dynamic pressures (e.g., lack of education, training, and appropriate skills, rapid urbanization, and perhaps even a decline in soil productivity), and those, in turn, within what are termed root causes. The root causes are implanted historically and structurally in the society by limited access to power, structures and resources, and ideologies of political and economic systems. The PAR model is shown diagrammatically in Figure 3.1, which illustrates that the disaster is crunched between the hazards on the one side, and the “progression of vulnerability” on the other.

Blaikie *et al.* (1994) consider that vulnerability is socially constructed. They also emphasize that vulnerability should be considered in applied disaster practices to release vulnerable people from the dynamic pressures. Thus, the applied practitioner can identify which variables lead to increased vulnerability, and thereby identify and develop those variables in order to reduce vulnerability. The PAR model has been criticized in failing to provide a systematic view of the mechanisms and processes of vulnerability. It has been argued that operationalizing this model necessarily involves typologies of causes and categorical data on hazard types, limiting the analysis in terms of quantifiable or predictive relationships (Adger, 2006). However, the PAR model, complementary to the access model, insists more on structural aspects and it is the only framework of disaster risk and vulnerability that clearly distinguishes between different causal levels (Nathan, 2011). The great merit of this model is to recognize that the deepest causal factors may often be quite remote from the disaster event itself.

Measures of vulnerability

In measuring human vulnerability at different scales, hazard researchers have used a large number of variables. Because many of these variables are strongly correlated, most of these researchers have developed a composite measure of vulnerability in general and social vulnerability in particular. They have examined a variety of hazard and disaster contexts identifying various dimensions of vulnerability. An examination of variables associated with vulnerability and composite indices will help in further developing appropriate indicators of vulnerability to extreme natural events.

Cutter *et al.* (2003) developed the Social Vulnerability Index (SoVI) for counties of the United States. Using the hazards-of-place model described earlier, they developed an index for social vulnerability. They collected relevant data for all US counties and used 42 variables (reduced by testing for multicollinearity from an original set of 250, and further reduced from a subset of 85 variables through application of conversion to percentages, per capita variables, and density function) as independents. Principal component analysis (PCA) was then applied in order to identify what variables describe the most variance within the data set. The PCA produced 11 factors that explained 76% of the variance across all US counties. The results showed that personal wealth (per capita income being the dominant variable) was the highest rated factor, explaining 12% of the variance in the dataset, followed by age (11.9%).

In Cutter *et al.*'s SoVI, levels and qualities of development figured importantly in two of their factors. The factor "density of the built environment" (density of commercial and manufacturing establishments, housing units, and new housing permits) explained 11.2% of the variance in the data set. The other factor titled "housing stock and tenancy" included variables such as the nature of the ownership of houses (whether rented or owned), the location of their residence (whether urban or not), and the nature of housing stock (whether or not it was a mobile home). In the United States, urban areas are more at risk for damaged dwellings while rural areas are at increased risk for destruction of mobile homes (Cutter *et al.*, 2003). In order to produce the SoVI, the authors then placed the factor scores for each county into an additive model that resulted in a composite index score of vulnerability for each county in the United States. The work of Cutter and her colleagues (2003) illustrates a collection of a wide range of variables narrowed down through intense statistical calculation, with the final result, the SoVI, producing one single number describing the potential for counties in the United States to be harmed by environmental disasters. The SoVI, however, indicates higher vulnerabilities based in part on population size. They also found that the most socially vulnerable counties were those with the most densely built environments. Of the 3141 US counties, 393 were classified as being most vulnerable. The utility of the index is in revealing the geographic distribution of vulnerability. If mitigation and prevention are the goal of the policymaker, they can apply this index to help them look more closely at parts of the United States that need assistance in building community resilience to hazard impacts.

In 2006 Cutter and Emrich applied the SoVI to an analysis of the counties and parishes along the Gulf Coast that were affected by Hurricane Katrina. They found the model to be a consistent and robust indicator of social vulnerability (Cutter and Emrich, 2006). In particular the SoVI was able to reveal how resiliency within a single county or parish had declined from one point in time to another (they used data from the decadal US Census). One policy application of the SoVI would be to reduce "overall social vulnerability" at the local level "by focusing mitigation and planning on the most important component for each community, rather than implementing broad-brush approaches that might miss the more intricate place-based differences in social vulnerability" (Cutter and Emrich, 2006, pp. 111–112).

Burton (2010) also developed a social vulnerability index for a selected census tract of Mississippi's Gulf Coast impacted by Hurricane Katrina. The SoVI provided the comparative framework for Burton's study.

As noted, Cutter *et al.* (2000) examined the vulnerability of Georgetown County, South Carolina, in terms of exposure to harm from technological and natural disasters. They used the term "place vulnerability" and claim that the interaction between biophysical and social vulnerability creates place vulnerability (Figure 3.2). Their place vulnerability was based on eight social (total population, total housing units, number of females, number of nonwhite residents, number of people under age 18, number of people over age 65, mean house value, and number of mobile homes) and 16 environmental factors (the frequency of 16 different environmental hazards). Both indices were developed for multiple hazards and they were not weighted.

Another application of vulnerability indices deals with coastal vulnerability, usually focused on the impact of hurricanes or storm surge associated with them. Dixon and Fitzsimons (2001) examined the vulnerability of Texas Gulf Coast communities to hurricanes. Using Saffir–Simpson intensity categories for historical hurricanes as well as population and property value data for each county, the authors developed an additive model resulting in five categories of risk scores and five exposure scores. Their Hurricane Vulnerability Index (HVI) is then derived by adding the two scores. This method illustrates an attempt to combine not only data on events that have already occurred, but to couple those data with the potential for harm to a county given the population and assumed worth of the property in that community, creating an index value that, while time-dependent, serves to assign a measure of potential loss in the event of a future hurricane.

In a similar work, Pethick and Crooks (2000) developed a Coastal Vulnerability Index (CVI) where they examined geomorphological factors such as exposure of cliffs, sand dunes, spits, and marshes in terms of their contribution to vulnerability of the coastal system as a whole. The CVI is relatively simple: vulnerability is considered as relaxation time divided by return interval of an erosion event. While the CVI is not as rigorous as the indices of Cutter *et al.* (2003) and Dixon and Fitzsimons (2001), it still offers insight into the different windows through which vulnerability can be viewed.

Since the terrorist attacks on September 11, 2001, attempts have been made to determine spatial vulnerability to agricultural bioterrorism. For example, the US Department of Homeland Security's Office for Domestic Preparedness (USDHS- ODP) issued both jurisdictional and state level security assessment handbooks to attempt to update threat, vulnerability, and response capabilities to terrorist activities on agricultural vulnerability in 2003 (USDHS-ODP, 2003a,b). Through a standardized form, this organization collected extensive data and subsequently calculated the vulnerability scores at both local and state levels to determine a vulnerability rating for the entire jurisdiction. Madden and Wheelis (2003) determined the threat of deliberately introduced plant pathogens as weapons against US crops. Stephen's (2004) analysis of vulnerability in Delanta, Ethiopia, focused on food security and global foreign aid. She utilized 12 variables (e.g., grazing land, crop land, dairy types available,

livestock holdings, crop sales prices, total income, and expenditure) to gauge the vulnerability of the rural population of Delanta.

Recently Mustafa *et al.* (2011) have developed a theoretically driven and empirically tested quantitative Vulnerability and Capacity Index (VCI) for use at the local scale. They used 12 indicators to represent material, institutional and attitudinal aspects of differential vulnerability and capacities to develop this index. One of the strengths of this VCI is that it looks at common core drivers of vulnerability across household and community scales and across rural and urban divides without changing drastically. The authors claim that the VCI is an attempt at a practical compromise that will help bridge the gap between research and fruitful policy.

Resilience

The terms vulnerability and resilience are highly complementary since greater resilience is what is achieved when vulnerability is reduced (Foster, 1995). Resilience and vulnerability reduction are compatible with the goals of sustainable development, broadly defined by the World Commission on Environment and Development (WCED) as: “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED, 1987, p. 188). Communities that are sustainable and resilient are able to minimize the effects of disasters, and at the same time, possess the ability to recover rapidly from these extreme events (Tobin, 1999).

The term resilience is derived from the Latin *resilio*, meaning “to jump back” (Klein *et al.*, 2003). From an engineering point of view, it is the ability of a material to recoil or spring back into shape after bending. The concept of resilience was introduced in 1973 by ecologist C.S. (Buzz) Holling (Walker *et al.*, 2006). He has drawn this widely contested concept from agro-ecology and natural resource management literature. Although resilience as a topic has been discussed among hazard researchers for more than three decades, this term gained prominence in the disaster literature after Hurricane Katrina in 2005, supplementing the concept of disaster resistance (Tierney and Bruneau, 2007). The 2004 World Disaster Report places resilience at the center of calls for stronger approaches to risk reduction that require local knowledge and implies a paradigm shift towards people-centered approaches as well as understanding of how communities and individuals survive and cope with disasters (IFRC, 2004).

Risk

Closely related to both vulnerability and resilience is the term “risk,” which has multiple conceptions and meanings. Like vulnerability, much has been written about the concept of risk, to the extent that it has crystallized into a full-fledged field of study (Alexander, 2000). As with both vulnerability and resilience, risk has also been a topic of interest to researchers in many disciplines for the last 40 years, and therefore many definitions of risk exist. For the same reason, the literature on this topic/concept is extensive and diverse. No wonder the concept of risk has varying meanings to

researchers in different disciplines. Even among risk managers, there is no single accepted definition for the term (Coppola, 2007). The objectives of this part of Chapter 3 are to cover essential facets of risk that are crucial to understanding this concept.

In the context of natural hazards, this concept is very important because it shapes both individual and collective perceptions and actions. It is also important for individual households and hazard-prone communities to take measures to reduce risk associated with extreme events. It is generally held that risk reduction by prior mitigation is cheaper than money spent on recovery and reconstruction after the occurrence of an extreme event. Burton and Pushchak (1984) divided the field of risk into three distinct parts: risk perception and communication, risk estimate/assessment, and risk management. For this discussion, risk perception and risk communication are treated separately. However, before covering these distinct aspects of risk, several definitions of risk are presented.

Risk assessment

Risk assessment refers to the determination of risk or a formal method for establishing the degree of risk an individual or a community faces from single or multiple hazards. A risk assessment can be either quantitative or qualitative. In the former case, an attempt is made to numerically determine probabilities of occurrence for extreme events and the likely extent of losses should a particular event take place. Qualitative risk analysis, which is used more often, involves neither estimating probabilities nor prediction of losses. Instead, qualitative methods involve defining the various threats, determining the extent of vulnerabilities, and devising countermeasures should an event occur.

Risk assessment represents the first step toward risk management and contains two components: a probability statement of an extreme event and its potential consequences or magnitude of the potential loss. Risk assessment for hazards is usually carried out by trained experts with the aim of producing reliable and repeatable results. Unfortunately, even experts may fail to reach to a consensus on the nature of risk. Differences in inference may result when experts measure risk based on risk perception and subjective judgments. Lack of data and/or differential data quality also creates this inferential problem. One of the key issues in risk assessment accounting for the differing views people hold regarding the importance of various risks.

In estimating the degree of risk, another challenge relates to determining acceptable risk, which is not easy to define. There is a need to clearly differentiate between acceptable risk, accepted risk, necessary risk, and tolerable risk. Acceptable risk is essentially the degree of human and material loss that is perceived as bearable for actions taken to reduce disaster risk (Blanchard, 2005). UNISDR (2004) defines it as: “The level of loss a society or community considers acceptable given existing social, economic, political, cultural, technical, and environmental conditions.”

As noted, tolerable risk is different from acceptable risk. The former represents temporarily acceptable risk. An individual may be willing to tolerate a risk because it is confined to a brief time period, or

associated with a short-term activity (Tobin and Montz, 1997). However, some risks are part of a lifestyle and thus are considered accepted risks. These risks are viewed as the consequence of living in hazardous environments, such as floodplains, coastal areas, and mountain slopes. Given the context, necessary risks are also accepted risks, but in a different context necessary risks may not be acceptable. One example of a response to a necessary risk might be to construct dykes to protect a community from flooding, rather than moving the community off the floodplain (Tobin and Montz, 1997).

Given that the provision of absolute safety is impossible, there is merit in trying to determine the level of risk which is acceptable to a society or a group for common activities or probable situations. One must always specify “acceptable to whom” and that implies a conscious decision based on all available information. In engineering terms, acceptable risk is used to assess structural and nonstructural measures undertaken to reduce possible damage to a level which does not harm people and property (UNISDR, 2004). In engineering, a popular way to define acceptable risk is to specify a recurrence interval, which expresses the failure rate of the systems. For example, the appropriate protection level for agricultural levees is determined by cost-benefit analysis, specially maximizing net benefits and considering incremental crop damage versus the added cost of raising a levee (Mileti, 1999).

Acceptable risk is a more policy-driven issue than a scientific one because many political, social, and/or economic factors influence the collective determination of what risks are acceptable and what risks are not. Two factors confounding the acceptability of risks are the benefits associated with certain risks, and the creation of new risks by eliminating existing ones. For example, dismantling of all nuclear power plants is needed to completely eliminate the risk from such facilities. However, the resulting shortage of power might require using more energy derived from coal or gas plants. This, in turn, would create increased carbon-based pollution, which would create increased health and environmental risks (Coppola, 2007).

There are three steps in risk assessment: type of hazard, probability of occurrence of the hazard, and estimate losses in terms of dollars of damage, fatalities, injuries, illnesses, or some other unit of analysis, such as loss of assets, loss of stockholder confidence, and loss of income. Items to consider in determining the probability of a specific disaster should include but not be limited to: geographic location, topography of the area, frequency of the disaster, and proximity to major highways. By its nature, risk assessment inherently incorporates uncertainty associated with determining the probability of an event occurring and the resulting magnitude of losses. It is difficult to quantify both components. The chance of error in the measurement of these two components is large. Fortunately, sensitivity analysis may help resolve some of the uncertainties associated with probability estimates.

Risk assessment should be thought of as a dynamic, ongoing process, not as a one-time project. The process is described as a set of steps that are continually repeated. At the outset, however, there is a startup process that usually is not repeated. There are several shortcomings of risk assessment. Such assessments tend to be overly quantitative and reductive. Risk assessment also usually ignores

qualitative differences among risks. Some maintain that risk assessments may omit important non quantifiable and/or inaccessible information, such as variations among classes of people exposed to hazards. Furthermore, quantitative approaches divert attention from precautionary or preventative measures. Others consider risk managers little more than “blind users” of statistical tools and methods (Paul, 2011).

UNIT-11: CONCEPTS OF HAZARD AND DISASTER MANAGEMENT

Mitigation

Mitigation refers to the policies and activities that attempt to reduce and/or eliminate individual and/or community vulnerability to damage from future disasters. Mitigation measures seek to “treat” the hazard such that it impacts individuals and communities to a lesser degree. Thus natural hazards have the potential to become disasters in the absence of mitigation measures. For this reason, the Federal Emergency Management Authority (FEMA) in the United States considers mitigation as the “cornerstone of disaster management” and it has defined mitigation as: “any cost-effective action taken to eliminate or reduce the long-term risk of life and property from natural and technological

hazards” (FEMA, n.d., p. 1). The phrase “cost-effective” is added to this definition to stress that a mitigation measure should save money over the long term. Since the 1970s there has been a growing interest in disaster mitigation programs from both public and private agencies. There is a large body of literature which urges governments to reallocate at least part of their budget from relief to mitigation.

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Mitigation goals

According to Coppola (2007), there are five major mitigation goals: risk likelihood reduction, risk consequences reduction, risk avoidance, risk acceptance, and risk transfer, sharing, or spreading.

These goals are closely associated with the phrase “alternative adjustments to natural hazards” or “theoretical range of adjustments to geophysical events” used in hazard geography (Burton *et al.*,

1968; Smith, 1992). Adjustments are defined as those human activities or measures intended to reduce or minimize negative impacts of an extreme event (White, 1974). These measures may be grouped in many different ways. Burton *et al.* (1968) for examples, classified these measures as: (i) affect in the cause, (ii) modifying the hazard, (iii) modifying loss potential or burden, (iv) an adjustment to losses by spreading out the losses, (v) planning for losses, and (vi) bearing the losses. The goals of mitigations are briefly discussed below.

Risk likelihood reduction

It is possible to reduce the likelihood of occurrence for several hazards. For example, flood frequency can be reduced through constructing dams, dikes, levees, flood walls, and bayous. These measures keep water away from the people up to the design stage of the structure. For some hazards, such as hurricanes and earthquakes, such interventions are not technically possible, at least at present. Mitigation measures that seek to reduce risk likelihood tend to be both structural and nonstructural in nature. The former measures use technological solutions, like dams and levees, while nonstructural measures include legislation, land use planning (e.g., the designation of nonessential land like parks to be used as flood zones), and insurance.

Risk consequences reduction

This goal acknowledges the fact that most disasters are unavoidable, but their consequences can be reduced through adopting mitigation measures such as the construction of safe rooms or public cyclone shelters. Since 1998, FEMA has recommended building safe rooms in tornado-prone areas in the United States. These are rooms that are anchored and armored to provide safe shelter during even the strongest of storms. They are made with thick concrete walls and a ceiling reinforced with steel bars. A safe room can be installed in a basement, in the center of the ground level of homes without a basement, or under a garage, the garage floor serving as the ceiling. One can also dig out a space beneath a reinforced entryway, using the large concrete slabs as protection from above (Murphy and Sherry, 2003). In the United States, safe rooms are in great demand in the tornado-prone state of Oklahoma, where basements are uncommon because of the ubiquitous hard clay soils (Murphy and Sherry, 2003). However, even a basement is no guarantee of protection from tornadoes for several reasons. Many basements, for example, are not fully underground, which makes them vulnerable to a degree. In addition, most basements have a wood floor overhead that could collapse when subjected to tornado-force winds. Public shelters are necessary in areas where disasters such as tornadoes or hurricanes/cyclones are likely. In the United States, it is desirable, but not often present to have community storm shelters near mobile/manufactured home parks. Mobile homes are highly vulnerable in tornado-prone areas. From 1985 to 2007, 43% of all tornado fatalities occurred in mobile/manufactured homes, yet these types of homes made up less than 8% of housing in the

tornado-prone areas studied (Sutter and Poitras, 2010). In 1972, the Bangladesh government began constructing public cyclone shelters in coastal areas to help save lives of coastal residents from cyclones and associated storm surges. These shelters are multi-storied reinforced concrete buildings, raised above ground level (to resist storm surges) and can accommodate 1500–2500 people (Paul *et al.*, 2002). Figure 5.2 illustrates a typical shelter built in the 1970s in coastal Bangladesh. Most of these cyclone shelters are used for multiple purposes during normal and disaster periods. In nondisaster periods, some of these buildings are used as schools, community centers, government offices, and elected local government (i.e., union council) offices. Many government development activities are also carried out in these shelters and are connected with surrounding neighbourhoods with flood-resistant access routes. Coastal embankments are another mitigation measure implemented in Bangladesh to reduce or prevent damage from cyclones and associated storm surges. The height of these embankments ranges from 17 to 20 feet (5–6 m) and they have marine and land-side slopes of 1:7 and 1:3, respectively. The Bangladesh government has also initiated a large afforestation project to provide protection for coastal residents and the beach environment against tidal and storm surges (Government of Bangladesh, 2008). Thus, some hazards have more than one option for disaster consequences reduction. Like the first goal, these measures tend to be both structural and nonstructural. The former includes both new and reinforced structures, which are able to withstand the negative impacts of disasters. These structures make it possible to live in cyclone-prone high-risk areas. Nonstructural measures include hazard forecasting and warning systems, and evacuation of potential victims from the projected path of an impending disaster. The risk consequences reduction goal also includes public awareness programs that provide residents with information on what to expect, what to do, and when to take action during an advancing disaster. Another way to reduce the consequences associated with a disaster is by identifying hazard zones and restricting or regulating their development (Coppola, 2007; Tobin and Montz, 1997).

Risk avoidance

The third mitigation goal is appropriate for disasters whose risks are great even after a partial reduction in either their likelihood or consequences. For these disasters total avoidance is necessary. This usually involves permanent evacuation of people and/or relocation of structures from a high-risk zone to a low- or no risk zone. Out-migration and buyout programs are examples of risk avoidance mitigation measures. The latter program seeks to physically remove people and structures within a floodplain and then restrict all future construction in that reclaimed land. Risk avoidance is also possible through relocation from volcanoes, avalanche chutes, and landslide zones.

Risk acceptance

This goal of mitigation is similar to adjustments which have been termed “bear the losses” – where people are willing to bear the full burden of damage or share it in some fashion with others (Burton *et al.*, 1968). No or extremely few places on the earth’s surface are free from natural hazards. A place may not experience all disaster types, but most locales are subject to a select number of hazards.

Residents of such places expect these hazards and they generally accept a certain risk associated with the disaster. For example, residents of floodplains expect river flooding and they are willing to bear some damage associated with flooding. It is to be noted that river flooding also has some benefits, such as increasing soil fertility due to the deposition of nutrient-rich silt. People who accept losses usually do not attempt to alter the cause(s) of disasters. They bear associated losses for several reasons. Often they perform a cost–benefit analysis and find out that an intended reduction measure for a particular hazard is not cost effective. In such a case, they will not pursue that particular measure, but may pursue a similar measure for other hazards for which that particular risk reduction measure will have greater value relative to losses usually incurred. Second, often some reduction mitigation measures will result in one or more undesirable consequences. Such a consequence may be considered more damaging or undesirable than impacts resulting from the hazard itself. Finally, for cultural or other reasons, residents of a particular place and location may prefer to stay there despite certain risks (Coppola, 2007).

Risk transfer, sharing, or spreading

The last and most debated mitigation goal is risk transfer, sharing, or spreading of financial losses incurred by disasters. Depending on the availability of disaster insurance, disaster-impacted communities and individuals can spread or transfer disaster loss or risk through insurance coverage. Insurance reduces the financial consequences of a disaster by transferring at least part of any monetary loss of property. It is important to mention that disaster insurance is still not available in many developing countries. Wherever it is available, coverage by insurance may be wholly voluntary or wholly mandatory, and large businesses often self-insure by setting up reserves and diversifying. However, in the United States, federal policy is aimed at encouraging local governments and individuals to insure public and private property against losses due to extreme natural events. The National Flood Insurance Program (NFIP) requires residents of flood-prone communities to carry flood insurance. Another way to transfer, share, or spread disaster loss is through the provision of relief and rehabilitation assistance, which is more common in developing countries than in developed countries. This assistance is generally offered to disaster victims by both public and private agencies. However, the availability of emergency relief may work against adoption of insurance by prospective disaster victims. Other ways to offset disaster losses include help from friends and relatives in various forms, such as cash, in kind, and labor. This is closely associated with the concept of social capital theory, which is defined by Pierre Bourdieu as the resources that can be derived through one's social network. It refers to the collective value of all "social networks" and the inclinations that arise from these networks to assist each other (Bourdieu, 1985).

Mitigation measure classification

As indicated, there are hundreds of mitigation measures which range from physical measures such as flood levees or safer building designs to nonphysical measures including legislation, training, and even public awareness campaign. Each hazard has a unique set of mitigation options from which

disaster managers may choose to engage/develop. Selection of mitigation options depend on costs, available funds, as well as the anticipated social and physical consequences of taking such actions. Mitigation measures can be classified in many different ways. For example, Mileti (1999) classified mitigation measures into five groups: land use planning/regulation, building codes and standards, insurance, engineering, and warning.

Land use planning and regulation

The main purpose of this measure is to reduce hazard exposure by land use management or zoning, and restricting construction of structures in hazard-prone areas. This is a regulatory measure where local government is responsible for preparing and following through land use planning and regulation for development in hazard-prone areas, prohibiting new construction in a floodplain, along a coast, or any other hazards-prone area. Among others, land use planning and regulation activities include enforcement of building codes and environmental regulations; public safety measures such as continual maintenance of roadways, culverts and dams; acquisition or relocation of properties such as purchasing buildings located in a floodplain; and retrofitting of structures and design of new construction such as elevating a home or building. Hazard-prone communities across the globe have implemented many regulatory and land use zoning mitigation measures. For example, after experiencing an F-4 tornado on April 21, 2001, the city of Hoisington, Kansas, enforced two new zoning ordinances that restricted the construction of homes on 50-foot lots in tornado-impacted portions of the city. This enforcement meant residents who were rebuilding had to purchase adjacent lots in order to satisfy the newly established requirements. As a result, housing density in the tornado-affected area became significantly lower than pre-tornado density and is also now lower than in non-impacted portion of the city (Brock and Paul, 2003). This ordinance has reduced exposure by limiting development and density of human occupancy in Hoisington.

Another new zoning regulation that went into effect in Hoisington was that any house constructed west of Alexandria Street could not have a basement because that area was identified by FEMA as being in a floodplain zone. Since everyone wanting to rebuild desired a basement, no one rebuilt their homes in that area. The city then bought this land and converted it into a park with new playground equipment and tennis courts. This change in land use was welcomed by an overwhelming majority of the residents of Hoisington – a town with a population of about 2000 in 2000 (Brock and Paul, 2003). Similarly, Cedar Falls, Iowa, a city of 36 145 people in 2000, bought 128 homes that were severely affected by a flood in 2008. Another 81 homes are in the process of being acquired by the city. All buyout properties will be used as a park or designated as a protected area (Rahman, 2010). In another example of reduced exposure through land use change, several small communities were relocated away from flood-prone areas after the widespread flooding experienced in the US Midwest in 1993 (Mileti, 1999). Most hazard regulatory measures are initiated by the central government, but such measures are often implemented by the local government. However, local governments are often reluctant to implement strict land use policies and regulatory measures due to a lack of local political

will to manage land use, and/or deficiencies in management capacity. Because the spatial extent of different natural hazards is usually well defined, land use planning and regulatory measures are particularly appropriate for specific geographic designations, such as flood plain and coastal zone management.

Building codes and standards

Building codes are a collection of laws, regulations, ordinances, or other statutory requirements adopted by a governmental legislative authority regarding the physical structure and/or construction of buildings. This group of mitigation measures is designed to ensure that structures resist the physical impacts created

by disasters and their purpose is to establish minimum acceptable requirements necessary for preserving the public health, safety, and welfare as well as the protection of property in the built environment. The primary application of building codes is to regulate new or proposed construction (Mileti, 1999). Although such codes may have little application to existing buildings (unless they are undergoing alteration), the effectiveness of zoning and other regulatory measures can be enhanced through the use of building codes.

Insurance

Most property owners in developed countries rely on private insurance to protect themselves against financial losses from some, but usually not all, natural disasters. Although insurance does not reduce actual disaster consequences or reduce hazard likelihood, it allows associated economic losses to be shared across a wide population. It should be noted that insurance often offers no incentives to undertake mitigation.

Engineering

This type of mitigation is frequently called structural mitigation, and involves physical measures taken to reduce disaster risk by erecting structures, such as cross-dams, and building a tornado safe room. Engineering measures also attempt to strengthen buildings to better withstand future disasters, such as tornadoes and earthquakes. This can be accomplished in two ways: the structure may be demolished and rebuilt to accommodate new hazard information or it may be modified so that it resists the anticipated external force (retrofitting). Thus, structural measures involve measures that relate to the existing natural and built environments and/or which address future developments.

Warning

A warning system is necessary to detect an impending disaster, communicate that information to people at risk, and encourage at risk population to take appropriate action. Disaster warning systems can make the difference between life and death. Lindell *et al.* (2005) maintain that the remarkable

reduction in US hurricane casualties since the 1900 Galveston hurricane was due to improved forecasting and warning systems coupled with timely and effective evacuations of coastal residents from imminent threats. However, in many countries, no comprehensive national warning system is available that covers all hazards and all places within a given country.

Critique of mitigation

There are several criticisms of mitigation. Mitigation projects tend to be large scale and high technology oriented, and thus very costly. Finding the fund to implement projects is often very challenging. A top-down approach is generally used to design and implement such projects. Mitigation projects are generally developed and managed by large centralized agencies without seeking input from disaster survivors. Because of their top-down approach, mitigation projects generally favor the rich and powerful at the expense of the most vulnerable. The emphasis of most mitigation programs has been on physical measures to address the immediate threat of a natural hazard and not on social changes to address the problem. Such programs only deal with reducing the risks of specific hazards and not on reducing the vulnerability of marginalized groups. So far, mitigation strategies have been designed to reduce the probability and impact of hazards, along with implementing anti-exposure measures, such as restricting development in floodplain zones. Anti-vulnerability mitigation measures (e.g., land reform and poverty alleviation) have received little, if any attention among hazard researchers as a means to reduce hazard risk. Reduction in vulnerability is necessary to build future resilience against hazards and disasters. Also, mitigation programs often do not take into account all the actual needs and demands of those affected by disasters. One of the greatest obstacles to mitigation is that those most impacted by a disaster often resist any alteration to their place of residence by land use changes and/or imposing new regulations for construction, including amending building codes. Citizens may have a vision of their community, their property, or their home that they are reluctant to alter. However, there are important reasons to mitigate against hazards. The most important is that it makes communities safer places to live. Increased safety brings a host of benefits that become apparent after a disaster, for example the cost of reconstruction is lower and the time it takes is shorter; businesses close for less time; public facilities require fewer repairs; and the community is running again sooner. In the long term, the community will be subject to fewer disasters.

Preparedness

Preparedness refers to the degree of alertness and readiness of an individual, a household, or a community against an impending disaster. Among many activities, preparedness includes such activities as formulating, testing and exercising disaster plans, providing hazard warnings, communicating with the public and others regarding disaster vulnerability and what to do to reduce it, evacuating people from harm's way, conducting emergency response drills, and providing disaster training for emergency responders and the general public (Tierney *et al.*, 2001). The acquisition of

equipment to support emergency action is also an important activity of hazard preparedness. Such activities ensure that the resources necessary for carrying out an effective response in shortest possible time are in place prior to the onset of a disaster or that they can be obtained promptly when needed. Preparedness minimizes the negative consequences of extreme events. It does not only facilitate effective response, but also enhances the ability of social units to effectively respond when a disaster does occur. Hazard preparedness is often divided into two categories: physical preparedness and social preparedness (Tierney *et al.*, 2001). The former centers on taking actions to ensure that facilities and structures can withstand disaster impacts and the buildings and their contents do not become a serious threat to life and property should a disaster strikes. Social preparedness includes actions (e.g., understanding what state and federal programs are available at the time of disaster, planning for situations involving hazard warning and evacuation, establishing emergency record-keeping systems, and developing disaster plans) to ensure that community organizations are able to adequately respond to the needs of victims in the event of a disaster. Both physical and social preparedness are seen as part of a five-phase preparedness cycle that consists of: (i) raising awareness, (ii) conducting hazards and vulnerability assessments, (iii) improving knowledge about hazard and how to cope with them, (iv) planning, and (v) practice (Tierney *et al.*, 2001). The preparedness process usually begins with a vulnerability analysis that attempts to identify what hazards could occur in a particular place and a risk analysis to determine the likely problems that an extreme event could impose. Numerous public and private emergency response agencies as well as individuals conduct disaster preparedness activities. Each agency and personnel has unique functions to perform and unique responsibilities to accomplish before disasters strike. Others along the path of an impending hazard need to be compliant with the directions provided by emergency management personnel.

Activities

As indicated, preparedness includes a range of activities and/or actions that are undertaken (at different levels) immediately and/or any time before a disaster which saves lives and minimize property damage. A number of preparedness activities are discussed below. This discussion is followed by an analysis of preparedness activities at four distinct levels: households, organizations, communities, and state and national preparedness. Factors that influence preparedness at each of these levels is also discussed.

Warning

Hazard warnings include a range of activities such as effective monitoring and accurate forecasting of a forthcoming event, developing warning messages, and disseminating the messages to those at risk. Before issuing a hazard warning, responsible authorities must identify what hazard is about to occur, is currently happening, or has already taken place. Detection and emergency assessment procedures differ by hazard types.

Evacuation

Evacuation is the primary protective action utilized in disasters such as floods, tsunamis, large wildfires, hurricanes/cyclones, and volcanic eruptions. It refers to the movement of people away from a potential or actual hazard impact area for the primary purpose of ensuring safety. Evacuation can take place before, during, or after a disaster occurs.

Exercise

One of the most effective ways to prepare for a disaster is to conduct practice exercises on a regular basis. The primary goal of such exercises is to improve operational readiness for people who participate in disaster response and recovery efforts. Exercises enhance a community's overall emergency management capabilities and provide useful tools for local programs to train emergency personnel and evaluate their operational readiness. Through exercises it is possible to identify shortcomings of emergency operations plans (EOP), reveal resource gaps, improve coordination and individual performance, and clarify roles and responsibilities of personnel involved in disaster activities. Disaster exercises also foster cooperation among government agencies and private sector resources, increase general awareness of proficiencies and needs, and verify the availability and utility of equipment (McEntire, 2007).

Household preparedness

Household level preparedness activities include: developing an emergency plan for the household, discussing preparedness plan (evacuation route) with family members, storing food and water, securing the home and contents, having a first-aid kit at home, making sure that there is a battery-powered radio on hand and a working flashlight, and taking other steps to prepare and anticipate whatever problems a disaster might create. Purchasing hazard insurance and making structural changes to the home are also household-level preparedness activities. Such household preparedness activities are disaster-specific.

Organizational preparedness

Both public and private organizations have disasters preparedness programs. Preparedness activities of these organizations include: developing emergency response plans and warning systems, identifying evacuation routes and shelters, acquiring needed equipment, supplies and materials, and maintaining emergency supplies and communication systems. Other preparedness activities include notifying and mobilizing key personnel, training employees and response personnel on what to do in an emergency situation, conducting exercises and drills, and informing citizens of risks, preparedness options, as well as the content and meaning of warning messages through education programs. There has been a tendency to focus on organizational preparedness only for specific kinds of hazards; this needs to be broadened to include all citizens as well as all hazards they might be impacted by.

Community preparedness

Like household and organizational preparedness, community preparedness encompasses a wide range of activity such as formulating plans, providing training for disaster responders and the general public to improve their understanding of what to do in a disaster, and conducting emergency drills and exercises.

State and national preparedness

In a country such as the United States where a federal system of government exists, state government plays a key role in disaster preparedness, both supporting communities impacted by disasters and coordinating with the federal government on a wide range of disaster-related tasks (Tierney *et al.*, 2001). State governments are required to develop their own disaster plans (Paul, 2011).

UNIT-12: CLIMATIC HAZARDS: TROPICAL CYCLONES (PREDICTION, PRECAUTION AND MITIGATION)

A **tropical cyclone** is a rapidly rotating storm system characterized by a low-pressure center, a closed low-level atmospheric circulation, strong winds, and a spiral arrangement of thunderstorms that produce heavy rain. Depending on its location and strength, a tropical cyclone is referred to by different names, including hurricane, typhoon, tropical storm, cyclonic storm, tropical depression, and simply cyclone. A hurricane is a tropical cyclone that occurs in the Atlantic Ocean and northeastern Pacific Ocean, and a typhoon occurs in the northwestern Pacific Ocean; in the south Pacific or Indian Ocean, comparable storms are referred to simply as "tropical cyclones" or "severe cyclonic storms".

"Tropical" refers to the geographical origin of these systems, which form almost exclusively over tropical seas. "Cyclone" refers to their winds moving in a circle, whirling round their central clear eye, with their winds blowing counter clockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere. The opposite direction of circulation is due to the Coriolis effect. Tropical cyclones typically form over large bodies of relatively warm water. They derive their energy through the evaporation of water from the ocean surface, which ultimately recondenses into clouds and rain when moist air rises and cools to saturation. This energy source differs from that of mid-latitude cyclonic storms, such as nor'easters and European windstorms, which are fuelled primarily by horizontal temperature contrasts. Tropical cyclones are typically between 100 and 2,000 km (62 and 1,243 mi) in diameter.

The strong rotating winds of a tropical cyclone are a result of the conservation of angular momentum imparted by the Earth's rotation as air flows inwards toward the axis of rotation. As a result, they rarely form within 5° of the equator. Tropical cyclones are almost unknown in the South Atlantic due to a consistently strong wind shear and a weak Intertropical Convergence Zone. Also,

the African easterly jet and areas of atmospheric instability which give rise to cyclones in the Atlantic Ocean and Caribbean Sea, along with the Asian monsoon and Western Pacific Warm Pool, are features of the Northern Hemisphere and Australia.

Coastal regions are particularly vulnerable to the impact of a tropical cyclone, compared to inland regions. The primary energy source for these storms is warm ocean waters, therefore these forms are typically strongest when over or near water, and weaken quite rapidly over land. Coastal damage may be caused by strong winds and rain, high waves (due to winds), storm surges (due to wind and severe pressure changes), and the potential of spawning tornadoes. Tropical cyclones also draw in air from a large area—which can be a vast area for the most severe cyclones—and concentrate the precipitation of the water content in that air (made up from atmospheric moisture and moisture evaporated from water) into a much smaller area. This continual replacement of moisture-bearing air by new moisture-bearing air after its moisture has fallen as rain, which may cause extremely heavy rain and river flooding up to 40 kilometres (25 mi) from the coastline, far beyond the amount of water that the local atmosphere holds at any one time.

Though their effects on human populations are often devastating, tropical cyclones can relieve drought conditions. They also carry heat energy away from the tropics and transport it toward temperate latitudes, which may play an important role in modulating regional and global climate.

Physical Structure

Tropical cyclones are areas of relatively low pressure in the troposphere, with the largest pressure perturbations occurring at low altitudes near the surface. On Earth, the pressures recorded at the centers of tropical cyclones are among the lowest ever observed at sea level. The environment near the center of tropical cyclones is warmer than the surroundings at all altitudes, thus they are characterized as "warm core" systems.

Wind field

The near-surface wind field of a tropical cyclone is characterized by air rotating rapidly around a center of circulation while also flowing radially inwards. At the outer edge of the storm, air may be nearly calm; however, due to the Earth's rotation, the air has non-zero absolute angular momentum. As air flows radially inward, it begins to rotate cyclonically (counter-clockwise in the Northern Hemisphere, and clockwise in the Southern Hemisphere) in order to conserve angular momentum. At an inner radius, air begins to ascend to the top of the troposphere. This radius is typically coincident with the inner radius of the eyewall, and has the strongest near-surface winds of the storm; consequently, it is known as the *radius of maximum winds*. Once aloft, air flows away from the storm's center, producing a shield of cirrus clouds.

The previously mentioned processes result in a wind field that is nearly axisymmetric: Wind speeds are low at the center, increase rapidly moving outwards to the radius of maximum winds, and then decay more gradually with radius to large radii. However, the wind field often exhibits additional spatial and temporal variability due to the effects of localized processes, such as thunderstorm activity and horizontal flow instabilities. In the vertical direction, winds are strongest near the surface and decay with height within the troposphere.

Eye and center

At the center of a mature tropical cyclone, air sinks rather than rises. For a sufficiently strong storm, air may sink over a layer deep enough to suppress cloud formation, thereby creating a clear "eye". Weather in the eye is normally calm and free of clouds, although the sea may be extremely violent. The eye is normally circular in shape, and is typically 30–65 km (19–40 mi) in diameter, though eyes as small as 3 km (1.9 mi) and as large as 370 km (230 mi) have been observed.

The cloudy outer edge of the eye is called the "eyewall". The eyewall typically expands outward with height, resembling an arena football stadium; this phenomenon is sometimes referred to as the "stadium effect". The eyewall is where the greatest wind speeds are found, air rises most rapidly, clouds reach to their highest altitude, and precipitation is the heaviest. The heaviest wind damage occurs where a tropical cyclone's eyewall passes over land.

In a weaker storm, the eye may be obscured by the central dense overcast, which is the upper-level cirrus shield that is associated with a concentrated area of strong thunderstorm activity near the center of a tropical cyclone.

The eyewall may vary over time in the form of eyewall replacement cycles, particularly in intense tropical cyclones. Outer rainbands can organize into an outer ring of thunderstorms that slowly moves inward, which is believed to rob the primary eyewall of moisture and angular momentum. When the primary eyewall weakens, the tropical cyclone weakens temporarily. The outer eyewall eventually replaces the primary one at the end of the cycle, at which time the storm may return to its original intensity.

Rapid deepening

On occasion, tropical cyclones may undergo a process known as rapid deepening, a period in which the minimum sea-level pressure of a tropical cyclone decreases by 42mb in a 24-hour period. In order for rapid deepening to occur, several conditions must be in place. Water temperatures must be extremely high (near or above 30 °C, 86 °F), and water of this temperature must be sufficiently deep such that waves do not upwell cooler waters to the surface. Wind shear must be low; when wind shear

is high, the convection and circulation in the cyclone will be disrupted. Usually, an anticyclone in the upper layers of the troposphere above the storm must be present as well—for extremely low surface pressures to develop, air must be rising very rapidly in the eyewall of the storm, and an upper-level anticyclone helps channel this air away from the cyclone efficiently.

Size

Size descriptions of tropical cyclones	
ROCI (Diameter)	Type
Less than 2 degrees latitude	Very small/minor
2 to 3 degrees of latitude	Small
3 to 6 degrees of latitude	Medium/Average/Normal
6 to 8 degrees of latitude	Large
Over 8 degrees of latitude	Very large

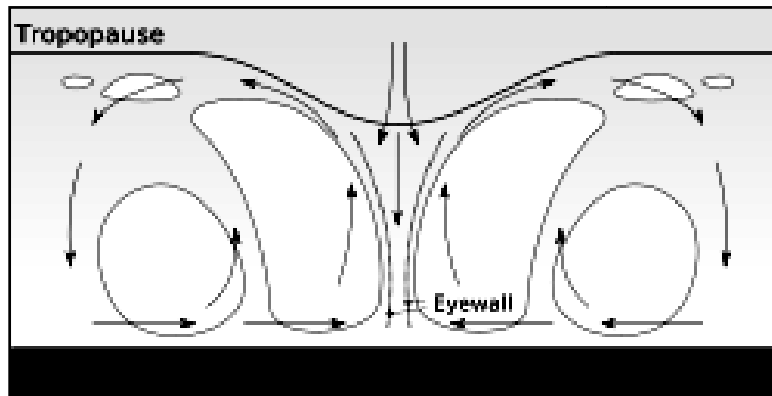
There are a variety of metrics commonly used to measure storm size. The most common metrics include the radius of maximum wind, the radius of 34-knot wind (i.e. gale force), the radius of outermost closed isobar (ROCI), and the radius of vanishing wind. An additional metric is the radius at which the cyclone's relative vorticity field decreases to $1 \times 10 \text{ s}$.

On Earth, tropical cyclones span a large range of sizes, from 100–2,000 kilometres (62–1,243 mi) as measured by the radius of vanishing wind. They are largest on average in the northwest Pacific Ocean basin and smallest in the northeastern Pacific Ocean basin. If the radius of outermost closed isobar is less than two degrees of latitude (222 km (138 mi)), then the cyclone is "very small" or a "midget". A radius of 3–6 latitude degrees (333–670 km (207–416 mi)) is considered "average sized". "Very large" tropical cyclones have a radius of greater than 8 degrees (888 km (552 mi)). Observations indicate that size is only weakly correlated to variables such as storm intensity (i.e. maximum wind speed), radius of maximum wind, latitude, and maximum potential intensity.

Size plays an important role in modulating damage caused by a storm. All else equal, a larger storm will impact a larger area for a longer period of time. Additionally, a larger near-surface wind field can generate higher storm surge due to the combination of longer wind fetch, longer duration, and enhanced wave setup.

The upper circulation of strong hurricanes extends into the tropopause of the atmosphere, which at low latitudes is 15,000–18,000 metres (50,000–60,000 ft).

Physics and energetic



Tropical cyclones exhibit an overturning circulation where air inflows at low levels near the surface, rises in thunderstorm clouds, and outflows at high levels near the tropopause.

The three-dimensional wind field in a tropical cyclone can be separated into two components: a "primary circulation" and a "secondary circulation". The primary circulation is the rotational part of the flow; it is purely circular. The secondary circulation is the overturning (in-up-out-down) part of the flow; it is in the radial and vertical directions. The primary circulation is larger in magnitude, dominating the surface wind field, and is responsible for the majority of the damage a storm causes, while the secondary circulation is slower but governs the energetics of the storm.

Secondary circulation: a Carnot heat engine

A tropical cyclone's primary energy source is heat from the evaporation of water from the surface of a warm ocean, previously heated by sunshine. The energetics of the system may be idealized as an atmospheric Carnot heat engine. First, inflowing air near the surface acquires heat primarily via evaporation of water (i.e. latent heat) at the temperature of the warm ocean surface (during evaporation, the ocean cools and the air warms). Second, the warmed air rises and cools within the eyewall while conserving total heat content (latent heat is simply converted to sensible heat during condensation). Third, air outflows and loses heat via infrared radiation to space at the temperature of the cold tropopause. Finally, air subsides and warms at the outer edge of the storm while conserving total heat content. The first and third legs are nearly isothermal, while the second and fourth legs are nearly isentropic. This in-up-out-down overturning flow is known as the secondary circulation. The Carnot perspective provides an upper bound on the maximum wind speed that a storm can attain.

Scientists estimate that a tropical cyclone releases heat energy at the rate of 50 to 200 exajoules (10 J) per day, equivalent to about 1 PW (10 watt). This rate of energy release is equivalent to 70 times the world energy consumption of humans and 200 times the worldwide electrical generating capacity, or to exploding a 10-megaton nuclear bomb every 20 minutes.

Formation

Times

In the Northern Atlantic Ocean, a distinct cyclone season occurs from June 1 to November 30, sharply peaking from late August through September. The statistical peak of the Atlantic hurricane season is September 10. The Northeast Pacific Ocean has a broader period of activity, but in a similar time frame to the Atlantic. The Northwest Pacific sees tropical cyclones year-round, with a minimum in February and March and a peak in early September. In the North Indian basin, storms are most common from April to December, with peaks in May and November. In the Southern Hemisphere, the tropical cyclone year begins on July 1 and runs all year-round encompassing the tropical cyclone seasons, which run from November 1 until the end of April, with peaks in mid-February to early March.

Basin	Season start	Season end	Tropical cyclones
North Atlantic	June 1	November 30	12.1
Eastern Pacific	May 15	November 30	16.6
Western Pacific	January 1	December 31	26.0
North Indian	January 1	December 31	4.8
South-West Indian	July 1	June 30	9.3
Australian region	November 1	April 30	11.0
Southern Pacific	November 1	April 30	7.3
Total:			87.1

Factors

The formation of tropical cyclones is the topic of extensive ongoing research and is still not fully understood. While six factors appear to be generally necessary, tropical cyclones may occasionally form without meeting all of the following conditions. In most situations, water temperatures of at least 26.5 °C (79.7 °F) are needed down to a depth of at least 50 m (160 ft); waters of this temperature

cause the overlying atmosphere to be unstable enough to sustain convection and thunderstorms. For tropical transitioning cyclones (i.e. Hurricane Ophelia (2017)) a water temperature of at least 22.5 °C (72.5 °F) has been suggested.

Another factor is rapid cooling with height, which allows the release of the heat of condensation that powers a tropical cyclone. High humidity is needed, especially in the lower-to-mid troposphere; when there is a great deal of moisture in the atmosphere, conditions are more favorable for disturbances to develop. Low amounts of wind shear are needed, as high shear is disruptive to the storm's circulation. Tropical cyclones generally need to form more than 555 km (345 mi) or five degrees of latitude away from the equator, allowing the Coriolis effect to deflect winds blowing towards the low pressure center and creating a circulation. Lastly, a formative tropical cyclone needs a preexisting system of disturbed weather. Tropical cyclones will not form spontaneously. Low-latitude and low-level westerly wind bursts associated with the Madden–Julian oscillation can create favorable conditions for tropical cyclogenesis by initiating tropical disturbances.

Locations

Most tropical cyclones form in a worldwide band of thunderstorm activity near the equator, referred to as the Intertropical Front (ITF), the Intertropical Convergence Zone (ITCZ), or the monsoon trough. Another important source of atmospheric instability is found in tropical waves, which contribute to the development of about 85% of intense tropical cyclones in the Atlantic Ocean and become most of the tropical cyclones in the Eastern Pacific. The majority forms between 10 and 30 degrees of latitude away of the equator, and 87% forms no farther away than 20 degrees north or south. Because the Coriolis effect initiates and maintains their rotation, tropical cyclones rarely form or move within 5 degrees of the equator, where the effect is weakest. However, it is still possible for tropical systems to form within this boundary as Tropical Storm Vamei and Cyclone Agni did in 2001 and 2004, respectively.

Movement

The movement of a tropical cyclone (i.e. its "track") is typically approximated as the sum of two terms: "steering" by the background environmental wind and "beta drift".

Environmental steering

Environmental steering is the dominant term. Conceptually, it represents the movement of the storm due to prevailing winds and other wider environmental conditions, similar to "leaves carried along by a stream". Physically, the winds, or flow field, in the vicinity of a tropical cyclone may be treated as having two parts: the flow associated with the storm itself, and the large-scale background flow of the environment in which the storm takes place. In this way, tropical cyclone motion may be represented to first-order simply as advection of the storm by the local environmental flow. This environmental flow is termed the "steering flow".

Climatologically, tropical cyclones are steered primarily westward by the east-to-west trade winds on the equatorial side of the subtropical ridge—a persistent high-pressure area over the world's subtropical oceans. In the tropical North Atlantic and Northeast Pacific oceans, the trade winds steer tropical easterly waves westward from the African coast toward the Caribbean Sea, North America, and ultimately into the central Pacific Ocean before the waves dampen out. These waves are the precursors to many tropical cyclones within this region. In contrast, in the Indian Ocean and Western Pacific in both hemispheres, tropical cyclogenesis is influenced less by tropical easterly waves and more by the seasonal movement of the Inter-tropical Convergence Zone and the monsoon trough. Additionally, tropical cyclone motion can be influenced by transient weather systems, such as extratropical cyclones.

Beta drift

In addition to environmental steering, a tropical cyclone will tend to drift slowly poleward and westward, a motion known as "beta drift". This motion is due to the superposition of a vortex, such as a tropical cyclone, onto an environment in which the Coriolis force varies with latitude, such as on a sphere or beta plane. It is induced indirectly by the storm itself, the result of a feedback between the cyclonic flow of the storm and its environment.

Physically, the cyclonic circulation of the storm advects environmental air poleward east of center and equatorial west of center. Because air must conserve its angular momentum, this flow configuration induces a cyclonic gyre equatorward and westward of the storm center and an anticyclonic gyre poleward and eastward of the storm center. The combined flow of these gyres acts to advect the storm slowly poleward and westward. This effect occurs even if there is zero environmental flow.

Multiple storm interaction

A third component of motion that occurs relatively infrequently involves the interaction of multiple tropical cyclones. When two cyclones approach one another, their centers will begin orbiting cyclonically about a point between the two systems. Depending on their separation distance and strength, the two vortices may simply orbit around one another or else may spiral into the center point and merge. When the two vortices are of unequal size, the larger vortex will tend to dominate the interaction, and the smaller vortex will orbit around it. This phenomenon is called the Fujiwhara effect, after Sakuhei Fujiwhara.

Interaction with the mid-latitude westerlies

Though a tropical cyclone typically moves from east to west in the tropics, its track may shift poleward and eastward either as it moves west of the subtropical ridge axis or else if it interacts with the mid-latitude flow, such as the jet stream or an extratropical cyclone. This motion, termed "recurvature", commonly occurs near the western edge of the major ocean basins, where the jet stream

typically has a poleward component and extratropical cyclones are common. An example of tropical cyclone recurvature was Typhoon Ioke in 2006.

Landfall

The landfall of a tropical cyclone occurs when a storm's surface center moves over a coastline. Storm conditions may be experienced on the coast and inland hours before landfall; in fact, a tropical cyclone can launch its strongest winds over land, yet not make landfall. NOAA uses the term "direct hit" to describe when a location (on the left side of the eye) falls within the radius of maximum winds (or twice that radius if on the right side), whether or not the hurricane's eye made landfall.

Changes caused by El Niño–Southern Oscillation

Most tropical cyclones form on the side of the subtropical ridge closer to the equator, then move poleward past the ridge axis before recurving into the main belt of the Westerlies. When the subtropical ridge position shifts due to El Niño, so will the preferred tropical cyclone tracks. Areas west of Japan and Korea tend to experience much fewer September–November tropical cyclone impacts during El Niño and neutral years. During El Niño years, the break in the subtropical ridge tends to lie near 130°E which would favor the Japanese archipelago. During El Niño years, Guam's chance of a tropical cyclone impact is one-third more likely than of the long-term average. The tropical Atlantic Ocean experiences depressed activity due to increased vertical wind shear across the region during El Niño years. During La Niña years, the formation of tropical cyclones, along with the subtropical ridge position, shifts westward across the western Pacific Ocean, which increases the landfall threat to China and much greater intensity in the Philippines.

Dissipation

Factors

A tropical cyclone can cease to have tropical characteristics in several different ways. One such way is if it moves over land, thus depriving it of the warm water it needs to power itself, quickly losing strength. Most strong storms lose their strength very rapidly after landfall and become disorganized areas of low pressure within a day or two, or evolve into extratropical cyclones. There is a chance a tropical cyclone could regenerate if it managed to get back over open warm water, such as with Hurricane Ivan. If it remains over mountains for even a short time, weakening will accelerate. Many storm fatalities occur in mountainous terrain, when diminishing cyclones unleash their moisture as torrential rainfall. This rainfall may lead to deadly floods and mudslides, as was the case with Hurricane Mitch around Honduras in October 1998. Without warm surface water, the storm cannot survive.

A tropical cyclone can dissipate when it moves over waters significantly below 26.5 °C (79.7 °F). This will cause the storm to lose its tropical characteristics, such as a warm core with thunderstorms

near the center, and become a remnant low-pressure area. These **remnant systems** may persist for up to several days before losing their identity. This dissipation mechanism is most common in the eastern North Pacific. Weakening or dissipation can occur if it experiences vertical wind shear, causing the convection and heat engine to move away from the center; this normally ceases development of a tropical cyclone. In addition, its interaction with the main belt of the Westerlies, by means of merging with a nearby frontal zone, can cause tropical cyclones to evolve into extratropical cyclones. This transition can take 1–3 days. Even after a tropical cyclone is said to be extratropical or dissipated, it can still have tropical storm force (or occasionally hurricane/typhoon force) winds and drop several inches of rainfall. In the Pacific Ocean and Atlantic Ocean, such tropical-derived cyclones of higher latitudes can be violent and may occasionally remain at hurricane or typhoon-force wind speeds when they reach the west coast of North America. These phenomena can also affect Europe, where they are known as *European windstorms*; Hurricane Iris's extratropical remnants are an example of such a windstorm from 1995. A cyclone can also merge with another area of low pressure, becoming a larger area of low pressure. This can strengthen the resultant system, although it may no longer be a tropical cyclone. Studies in the 2000s have given rise to the hypothesis that large amounts of dust reduce the strength of tropical cyclones.

Artificial dissipation

In the 1960s and 1970s, the United States government attempted to weaken hurricanes through Project Stormfury by seeding selected storms with silver iodide. It was thought that the seeding would cause supercooled water in the outer rainbands to freeze, causing the inner eyewall to collapse and thus reducing the winds. The winds of Hurricane Debbie—a hurricane seeded in Project Stormfury—dropped as much as 31%, but Debbie regained its strength after each of two seeding forays. In an earlier episode in 1947, disaster struck when a hurricane east of Jacksonville, Florida promptly changed its course after being seeded, and smashed into Savannah, Georgia. Because there was so much uncertainty about the behavior of these storms, the federal government would not approve seeding operations unless the hurricane had a less than 10% chance of making landfall within 48 hours, greatly reducing the number of possible test storms. The project was dropped after it was discovered that eyewall replacement cycles occur naturally in strong hurricanes, casting doubt on the result of the earlier attempts. Today, it is known that silver iodide seeding is not likely to have an effect because the amount of supercooled water in the rainbands of a tropical cyclone is too low.

Other approaches have been suggested over time, including cooling the water under a tropical cyclone by towing icebergs into the tropical oceans. Other ideas range from covering the ocean in a substance that inhibits evaporation, dropping large quantities of ice into the eye at very early stages of development (so that the latent heat is absorbed by the ice, instead of being converted to kinetic energy that would feed the positive feedback loop), or blasting the cyclone apart with nuclear weapons. Project Cirrus even involved throwing dry ice on a cyclone. These approaches all suffer

from one flaw above many others: tropical cyclones are simply too large and long-lived for any of the weakening techniques to be practical.

Effects

Tropical cyclones out at sea cause large waves, heavy rain, flood and high winds, disrupting international shipping and, at times, causing shipwrecks. Tropical cyclones stir up water, leaving a cool wake behind them, which causes the region to be less favorable for subsequent tropical cyclones. On land, strong winds can damage or destroy vehicles, buildings, bridges, and other outside objects, turning loose debris into deadly flying projectiles. The storm surge, or the increase in sea level due to the cyclone, is typically the worst effect from landfalling tropical cyclones, historically resulting in 90% of tropical cyclone deaths. The broad rotation of a landfalling tropical cyclone, and vertical wind shear at its periphery, spawns tornadoes. Tornadoes can also be spawned as a result of eyewall mesovortices, which persist until landfall.

Over the past two centuries, tropical cyclones have been responsible for the deaths of about 1.9 million people worldwide. Large areas of standing water caused by flooding lead to infection, as well as contributing to mosquito-borne illnesses. Crowded evacuees in shelters increase the risk of disease propagation. Tropical cyclones significantly interrupt infrastructure, leading to power outages, bridge destruction, and the hampering of reconstruction efforts. On average, the Gulf and east coasts of the United States suffer approximately US\$5 billion (1995 US \$) in cyclone damage every year. The majority (83%) of tropical cyclone damage is caused by severe hurricanes, category 3 or greater. However, category 3 or greater hurricanes only account for about one-fifth of cyclones that make landfall every year.

Although cyclones take an enormous toll in lives and personal property, they may be important factors in the precipitation regimes of places they impact, as they may bring much-needed precipitation to otherwise dry regions. Tropical cyclones also help maintain the global heat balance by moving warm, moist tropical air to the middle latitudes and polar regions, and by regulating the thermohaline circulation through upwelling. The storm surge and winds of hurricanes may be destructive to human-made structures, but they also stir up the waters of coastal estuaries, which are typically important fish breeding locales. Tropical cyclone destruction spurs redevelopment, greatly increasing local property values.

When hurricanes surge upon shore from the ocean, salt is introduced to many freshwater areas and raises the salinity levels too high for some habitats to withstand. Some are able to cope with the salt and recycle it back into the ocean, but others can not release the extra surface water quickly enough or do not have a large enough freshwater source to replace it. Because of this, some species of plants and vegetation die due to the excess salt. In addition, hurricanes can carry toxins and acids onto shore

when they make landfall. The flood water can pick up the toxins from different spills and contaminate the land that it passes over. The toxins are very harmful to the people and animals in the area, as well as the environment around them. The flooding water can also spark many dangerous oil spills.

Preparedness and response

Hurricane preparedness encompasses the actions and planning taken before a tropical cyclone strikes to mitigate damage and injury from the storm. Knowledge of tropical cyclone impacts on an area help plan for future possibilities. Preparedness may involve preparations made by individuals as well as centralized efforts by governments or other organizations. Tracking storms during the tropical cyclone season helps individuals know current threats. Regional Specialized Meteorological Centers and Tropical Cyclone Warning Centers provide current information and forecasts to help individuals make the best decision possible.

Hurricane response is the disaster response after a hurricane. Activities performed by hurricane responders include assessment, restoration, and demolition of buildings; removal of debris and waste; repairs to land-based and maritime infrastructure; and public health services including search and rescue operations. Hurricane response requires coordination between federal, tribal, state, local, and private entities. According to the National Voluntary Organizations Active in Disaster, potential response volunteers should affiliate with established organizations and should not self-deploy, so that proper training and support can be provided to mitigate the danger and stress of response work.

Hurricane responders face many hazards. Hurricane responders may be exposed to chemical and biological contaminants including stored chemicals, sewage, human remains, and mold growth encouraged by flooding, as well as asbestos and lead that may be present in older buildings. Common injuries arise from falls from heights, such as from a ladder or from level surfaces; from electrocution in flooded areas, including from backfeed from portable generators; or from motor vehicle accidents. Long and irregular shifts may lead to sleep deprivation and fatigue, increasing the risk of injuries, and workers may experience mental stress associated with a traumatic incident. Additionally, heat stress is a concern as workers are often exposed to hot and humid temperatures, wear protective clothing and equipment, and have physically difficult tasks.

Observation and forecasting

Observation

Intense tropical cyclones pose a particular observation challenge, as they are a dangerous oceanic phenomenon, and weather stations, being relatively sparse, are rarely available on the site of the storm itself. In general, surface observations are available only if the storm is passing over an island or a coastal area, or if there is a nearby ship. Real-time measurements are usually taken in the periphery of the cyclone, where conditions are less catastrophic and its true strength cannot be evaluated. For this

reason, there are teams of meteorologists that move into the path of tropical cyclones to help evaluate their strength at the point of landfall.

Tropical cyclones far from land are tracked by weather satellites capturing visible and infrared images from space, usually at half-hour to quarter-hour intervals. As a storm approaches land, it can be observed by land-based Doppler weather radar. Radar plays a crucial role around landfall by showing a storm's location and intensity every several minutes.

In situ measurements, in real-time, can be taken by sending specially equipped reconnaissance flights into the cyclone. In the Atlantic basin, these flights are regularly flown by United States government hurricane hunters. The aircraft used are WC-130 Hercules and WP-3D Orions, both four-engine turboprop cargo aircraft. These aircraft fly directly into the cyclone and take direct and remote-sensing measurements. The aircraft also launch GPS dropsondes inside the cyclone. These sondes measure temperature, humidity, pressure, and especially winds between flight level and the ocean's surface. A new era in hurricane observation began when a remotely piloted Aerosonde, a small drone aircraft, was flown through Tropical Storm Ophelia as it passed Virginia's Eastern Shore during the 2005 hurricane season. A similar mission was also completed successfully in the western Pacific Ocean. This demonstrated a new way to probe the storms at low altitudes that human pilots seldom dare.

Forecasting

Because of the forces that affect tropical cyclone tracks, accurate track predictions depend on determining the position and strength of high- and low-pressure areas, and predicting how those areas will change during the life of a tropical system. The deep layer mean flow, or average wind through the depth of the troposphere, is considered the best tool in determining track direction and speed. If storms are significantly sheared, use of wind speed measurements at a lower altitude, such as at the 70 kPa pressure surface (3,000 metres or 9,800 feet above sea level) will produce better predictions. Tropical forecasters also consider smoothing out short-term wobbles of the storm as it allows them to determine a more accurate long-term trajectory. High-speed computers and sophisticated simulation software allow forecasters to produce computer models that predict tropical cyclone tracks based on the future position and strength of high- and low-pressure systems. Combining forecast models with increased understanding of the forces that act on tropical cyclones, as well as with a wealth of data from Earth-orbiting satellites and other sensors, scientists have increased the accuracy of track forecasts over recent decades. However, scientists are not as skillful at predicting the intensity of tropical cyclones. The lack of improvement in intensity forecasting is attributed to the complexity of tropical systems and an incomplete understanding of factors that affect their development. New tropical cyclone position and forecast information is available at least every twelve hours in the Southern Hemisphere and at least every six hours in the Northern Hemisphere from Regional Specialized Meteorological Centers and Tropical Cyclone Warning Centers.

Classifications, terminology naming

Intensity classifications

Tropical cyclones are classified into three main groups, based on intensity: tropical depressions, tropical storms, and a third group of more intense storms, whose name depends on the region. For example, if a tropical storm in the Northwestern Pacific reaches hurricane-strength winds on the Beaufort scale, it is referred to as a *typhoon*; if a tropical storm passes the same benchmark in the Northeast Pacific Basin, or in the North Atlantic, it is called a *hurricane*. Neither "hurricane" nor "typhoon" is used in either the Southern Hemisphere or the Indian Ocean. In these basins, storms of a tropical nature are referred to as either tropical cyclones, severe tropical cyclones or very intense tropical cyclones.

As indicated in the table below, each basin uses a separate system of terminology, which can make comparisons between different basins difficult. In the Pacific Ocean, hurricanes from the Central North Pacific sometimes cross the 180th meridian into the Northwest Pacific, becoming typhoons (such as Hurricane/Typhoon Ioke in 2006); on rare occasions, the reverse will occur. It should also be noted that typhoons with 1-minute sustained winds greater than 67 metres per second (m/s), over 150 miles per hour (240 km/h), are called *Super Typhoons* by the Joint Typhoon Warning Center.

Although not strictly tropical (or even subtropical) cyclonic systems like depressions, storms and hurricanes/typhoons, the National Hurricane Center, Central Pacific Hurricane Center, and Joint Typhoon Warning Center also monitor and designate certain areas of interest (also called invests) for potential cyclonic activity, sometimes classifying them as potential tropical cyclones as an unofficial fourth category.

Potential tropical cyclone

If a tropical disturbance (not yet developed into a tropical depression) is capable of producing tropical storm or hurricane conditions on land within 48 hours, then it will be classified by the NHC, CPHC, or JTWC as a **potential tropical cyclone** (PTC).

Tropical depression

A **tropical depression** or **tropical low** is a tropical disturbance that has a clearly defined surface circulation with maximum sustained winds of less than 34 kn (39 mph; 63 km/h). Within the Southern Hemisphere, the depression can have gale force or stronger winds in one or more quadrants, but not near the centre.

Tropical storm

A **tropical storm** is an organized system of strong thunderstorms with a defined surface circulation and maximum sustained winds between 34 knots (63 km/h) and 64 knots (119 km/h). At this point,

the distinctive cyclonic shape starts to develop, although an eye is not usually present. Government weather services first assign names to systems that reach this intensity (thus the term *named storm*). Although tropical storms are less intense than a hurricane they can produce significant damage. The shear force of winds can blow off shingles, and air borne objects can cause damage to power lines, roofing and siding. More dangerous is the heavy rainfall causing inland flooding.

Hurricane or typhoon

A **hurricane** or **typhoon** (sometimes simply referred to as a tropical cyclone, as opposed to a depression or storm) is a system with sustained winds of at least 64 kn (74 mph; 119 km/h; 33 m/s). A cyclone of this intensity tends to develop an eye, an area of relative calm (and lowest atmospheric pressure) at the center of circulation. The eye is often visible in satellite images as a small, circular, cloud-free spot. Surrounding the eye is the eyewall, an area about 16 kilometres (9.9 mi) to 80 kilometres (50 mi) wide in which the strongest thunderstorms and winds circulate around the storm's center. Maximum sustained winds in the strongest tropical cyclones have been estimated at about 95 m/s (185 kn; 210 mph; 340 km/h).

Origin of storm terms

The word *typhoon*, which is used today in the Northwest Pacific, may be derived from Arabic *ṭūfān* (similar in Hindustani and Persian), or Greek *Typhon* (Τυφών) (a monster from Greek mythology associated with storms) or Chinese "táifēng". The word *hurricane*, used in the North Atlantic and Northeast Pacific, is derived from *huracán*, the Spanish word for the Carib/Taino storm god, Juracán. This god is believed by scholars to have been at least partially derived from the Mayan creator god, Huracan. Huracan was believed by the Maya to have created dry land out of the turbulent waters. The god was also credited with later destroying the "wooden people", the precursors to the "maize people", with an immense storm and flood. Huracan is also the source of the word *orcan*, another word for a particularly strong European windstorm.

Numbering

Almost all tropical and subtropical cyclones, even if not developed enough to be formally assigned names, are assigned numbers by the warning centers tasked with monitoring them.

For example, systems (tropical, subtropical, or even potential tropical) forming in the North Atlantic and North Pacific basins (in an official manner), as well as those originating in other areas (in an unofficial basis) serving United States government interests (both civilian and military), are assigned *tropical cyclone numbers* (or *TC numbers* for short) by the National Hurricane Center, the Central Pacific Hurricane Center, and the Joint Typhoon Warning Center. A TC number is a two-

digit number (starting each year/season with "01" and running upwards) followed by (except for the North Atlantic basin) a suffix letter corresponding to the basin of origin (like "E" for Eastern Pacific, "C" for Central Pacific, and "W" for Western Pacific); the number is often spelled-out in English (like "ONE", sometimes appended with a hyphen and the basin suffix as in "ONE-E") for the purpose of generating a placeholder name for a (sub)tropical depression or an otherwise yet-unnamed storm (especially in JTWC-tracked areas where differences in wind scales result in one agency upgrading the system to a storm without the other following suit).

Examples of TC numbers are *PTC 08* for a North Atlantic potential tropical cyclone *EIGHT*, *TD 21E* for an East Pacific tropical depression *TWENTYONE-E*, and *SD 03C* for a Central Pacific subtropical depression *THREE-C*. TC numbers are hard-limited to a maximum of "49" by the Automated Tropical Cyclone Forecasting System; however, the NHC and the CPHC usually limit this to "30"; also, TC numbers are not recycled until the next year/season. This numbering system is similar to that used for invests, except invests are numbered from "90" to "99" (which are rotated and recycled within the same year/season) and explicitly specify suffix "L" for North Atlantic systems.

Naming

The practice of using names to identify tropical cyclones goes back many years, with systems named after places or things they hit before the formal start of naming. The system currently used provides positive identification of severe weather systems in a brief form, that is readily understood and recognized by the public. The credit for the first usage of personal names for weather systems is generally given to the Queensland Government Meteorologist Clement Wragge who named systems between 1887 and 1907. This system of naming weather systems subsequently fell into disuse for several years after Wragge retired, until it was revived in the latter part of World War II for the Western Pacific. Formal naming schemes have subsequently been introduced for the North and South Atlantic, Eastern, Central, Western and Southern Pacific basins as well as the Australian region and Indian Ocean.

At present tropical cyclones are officially named by one of eleven meteorological services and retain their names throughout their lifetimes to provide ease of communication between forecasters and the general public regarding forecasts, watches, and warnings. Since the systems can last a week or longer and more than one can be occurring in the same basin at the same time, the names are thought to reduce the confusion about what storm is being described. Names are assigned in order from predetermined lists with one, three, or ten-minute sustained wind speeds of more than 65 km/h (40 mph) depending on which basin it originates. However, standards vary from basin to basin with some tropical depressions named in the Western Pacific, while tropical cyclones have to have a significant amount of gale-force winds occurring around the center before they are named within the Southern Hemisphere. The names of significant tropical cyclones in the North Atlantic Ocean,

Pacific Ocean, and Australian region are retired from the naming lists and replaced with another name.

Long term activity trends

While the number of storms in the Atlantic has increased since 1995, there is no obvious global trend; the annual number of tropical cyclones worldwide remains about 87 ± 10 (Between 77 and 97 tropical cyclones annually). However, the ability of climatologists to make long-term data analysis in certain basins is limited by the lack of reliable historical data in some basins, primarily in the Southern Hemisphere, while noting that a significant downward trend in tropical cyclone numbers has been identified for the region near Australia (based on high quality data and accounting for the influence of the El Niño-Southern Oscillation). In spite of that, there is some evidence that the intensity of hurricanes is increasing. Kerry Emanuel stated, "Records of hurricane activity worldwide show an upswing of both the maximum wind speed in and the duration of hurricanes. The energy released by the average hurricane (again considering all hurricanes worldwide) seems to have increased by around 70% in the past 30 years or so, corresponding to about a 15% increase in the maximum wind speed and a 60% increase in storm lifetime."

Atlantic storms are becoming more destructive financially, as evidenced by the fact that five of the ten most expensive storms in United States history have occurred since 1990. According to the World Meteorological Organization, "recent increase in societal impact from tropical cyclones has been caused largely by rising concentrations of population and infrastructure in coastal regions." Political scientist Pielke *et al.* (2008) normalized mainland US hurricane damage from 1900–2005 to 2005 values and found no remaining trend of increasing absolute damage. The 1970s and 1980s were notable because of the extremely low amounts of damage compared to other decades. The decade 1996–2005 was the second most damaging among the past 11 decades, with only the decade 1926–1935 surpassing its costs.

Often in part because of the threat of hurricanes, many coastal regions had sparse population between major ports until the advent of automobile tourism; therefore, the most severe portions of hurricanes striking the coast may have gone unmeasured in some instances. The combined effects of ship destruction and remote landfall severely limit the number of intense hurricanes in the official record before the era of hurricane reconnaissance aircraft and satellite meteorology. Although the record shows a distinct increase in the number and strength of intense hurricanes, therefore, experts regard the early data as suspect.

The number and strength of Atlantic hurricanes may undergo a 50–70 year cycle, also known as the Atlantic Multidecadal Oscillation. Nyberg *et al.* reconstructed Atlantic major hurricane activity back to the early 18th century and found five periods averaging 3–5 major hurricanes per year and lasting 40–60 years, and six other averaging 1.5–2.5 major hurricanes per year and lasting 10–20 years. These periods are associated with the Atlantic multidecadal oscillation. Throughout, a

decadal oscillation related to solar irradiance was responsible for enhancing/dampening the number of major hurricanes by 1–2 per year.

Although more common since 1995, few above-normal hurricane seasons occurred during 1970–94. Destructive hurricanes struck frequently from 1926 to 1960, including many major New England hurricanes. Twenty-one Atlantic tropical storms formed in 1933, a record only recently exceeded in 2005, which saw 28 storms. Tropical hurricanes occurred infrequently during the seasons of 1900–25; however, many intense storms formed during 1870–99. During the 1887 season, 19 tropical storms formed, of which a record 4 occurred after November 1 and 11 strengthened into hurricanes. Few hurricanes occurred in the 1840s to 1860s; however, many struck in the early 19th century, including an 1821 storm that made a direct hit on New York City. Some historical weather experts say these storms may have been as high as Category 4 in strength.

These active hurricane seasons predated satellite coverage of the Atlantic basin. Before the satellite era began in 1960, tropical storms or hurricanes went undetected unless a reconnaissance aircraft encountered one, a ship reported a voyage through the storm, or a storm hit land in a populated area.

Proxy records based on paleotempestological research have revealed that major hurricane activity along the Gulf of Mexico coast varies on timescales of centuries to millennia. Few major hurricanes struck the Gulf coast during 3000–1400 BC and again during the most recent millennium. These quiescent intervals were separated by a hyperactive period during 1400 BC and 1000 AD, when the Gulf coast was struck frequently by catastrophic hurricanes and their landfall probabilities increased by 3–5 times. This millennial-scale variability has been attributed to long-term shifts in the position of the Azores High, which may also be linked to changes in the strength of the North Atlantic oscillation.

According to the Azores High hypothesis, an anti-phase pattern is expected to exist between the Gulf of Mexico coast and the Atlantic coast. During the quiescent periods, a more north easterly position of the Azores High would result in more hurricanes being steered towards the Atlantic coast. During the hyperactive period, more hurricanes were steered towards the Gulf coast as the Azores High was shifted to a more southwesterly position near the Caribbean. Such a displacement of the Azores High is consistent with paleoclimatic evidence that shows an abrupt onset of a drier climate in Haiti around 3200 C years BP, and a change towards more humid conditions in the Great Plains during the late-Holocene as more moisture was pumped up the Mississippi Valley through the Gulf coast. Preliminary data from the northern Atlantic coast seem to support the Azores High hypothesis. A 3000-year proxy record from a coastal lake in Cape Cod suggests that hurricane activity increased significantly during the past 500–1000 years, just as the Gulf coast was amid a quiescent period of the last millennium.

Climate change

The 2007 IPCC report noted many observed changes in the climate, including atmospheric composition, global average temperatures, ocean conditions, and others. The report concluded the

observed increase in tropical cyclone intensity is larger than climate models predict. In addition, the report considered that it is likely that storm intensity will continue to increase through the 21st century, and declared it more likely than not that there has been some human contribution to the increases in tropical cyclone intensity.

P.J. Webster and others published in 2005 an article in *Science* examining the "changes in tropical cyclone number, duration, and intensity" over the past 35 years, the period when satellite data has been available. Their main finding was although the number of cyclones decreased throughout the planet excluding the north Atlantic Ocean, there was a great increase in the number and proportion of very strong cyclones.

According to 2006 studies by the National Oceanic and Atmospheric Administration, "the strongest hurricanes in the present climate may be upstaged by even more intense hurricanes over the next century as the earth's climate is warmed by increasing levels of greenhouse gases in the atmosphere".

Studies published since 2008, by Kerry Emanuel from MIT, indicate that global warming is likely to increase the intensity but decrease the frequency of hurricane and cyclone activity. In an article in *Nature*, Kerry Emanuel stated that potential hurricane destructiveness, a measure combining hurricane strength, duration, and frequency, "is highly correlated with tropical sea surface temperature, reflecting well-documented climate signals, including multidecadal oscillations in the North Atlantic and North Pacific, and global warming". Emanuel predicted "a substantial increase in hurricane-related losses in the twenty-first century".

Research reported in the September 3, 2008 issue of *Nature* found that the strongest tropical cyclones are getting stronger, in particular over the North Atlantic and Indian oceans. Wind speeds for the strongest tropical storms increased from an average of 225 km/h (140 mph) in 1981 to 251 km/h (156 mph) in 2006, while the ocean temperature, averaged globally over all the regions where tropical cyclones form, increased from 28.2 °C (82.8 °F) to 28.5 °C (83.3 °F) during this period.

A 2017 study looked at compounding effects from floods, storm surge, and terrestrial flooding (rivers), and projects an increase due to global warming.

Related cyclone types

In addition to tropical cyclones, there are two other classes of cyclones within the spectrum of cyclone types. These kinds of cyclones, known as extratropical cyclones and subtropical cyclones, can be stages a tropical cyclone passes through during its formation or dissipation. An *extratropical cyclone* is a storm that derives energy from horizontal temperature differences, which are typical in higher latitudes. A tropical cyclone can become extratropical as it moves toward higher latitudes if its energy source changes from heat released by condensation to differences in temperature between air masses; although not as frequently, an extratropical cyclone can transform into a subtropical storm, and from there into a tropical cyclone. From space, extratropical storms have a characteristic "comma-

shaped" cloud pattern. Extratropical cyclones can also be dangerous when their low-pressure centers cause powerful winds and high seas.

A subtropical cyclone is a weather system that has some characteristics of a tropical cyclone and some characteristics of an extratropical cyclone. They can form in a wide band of latitudes, from the equator to 50°. Although subtropical storms rarely have hurricane-force winds, they may become tropical in nature as their cores warm. From an operational standpoint, a tropical cyclone is usually not considered to become subtropical during its extratropical transition.

Popular culture

In popular culture, tropical cyclones have made several appearances in different types of media, including films, books, television, music, and electronic games. These media often portray tropical cyclones that are either entirely fictional or based on real events. For example, George Rippey Stewart's *Storm*, a best-seller published in 1941, is thought to have influenced meteorologists on their decision to assign female names to Pacific tropical cyclones. Another example is the hurricane in *The Perfect Storm*, which describes the sinking of the *Andrea Gail* by the 1991 Perfect Storm. Hypothetical hurricanes have been featured in parts of the plots of series such as *The Simpsons*, *Invasion*, *Family Guy*, *Seinfeld*, *Dawson's Creek*, *Burn Notice* and *CSI: Miami*. The 2004 film *The Day After Tomorrow* includes several mentions of actual tropical cyclones and features fantastical "hurricane-like", albeit non-tropical, Arctic storms (Tropical Cyclone).

UNIT-13: MARINE/ TECTONIC HAZARD: TSUNAMI (PREDICTION, PRECAUTION AND MITIGATION)

A **tsunami** or **tidal wave**,, also known as a **seismic sea wave**, is a series of waves in a water body caused by the displacement of a large volume of water, generally in an ocean or a large lake. Earthquakes, volcanic eruptions and other underwater explosions (including detonations, landslides, glacier calvings, meteorite impacts and other disturbances) above or below water all have the potential to generate a tsunami. Unlike normal ocean waves, which are generated by wind, or tides, which are generated by the gravitational pull of the Moon and the Sun, a tsunami is generated by the displacement of water.

Tsunami waves do not resemble normal undersea currents or sea waves because their wavelength is far longer. Rather than appearing as a breaking wave, a tsunami may instead initially resemble a rapidly rising tide. For this reason, it is often referred to as a "tidal wave", although this usage is not favoured by the scientific community because it might give the false impression of a causal relationship between tides and tsunamis. Tsunamis generally consist of a series of waves, with periods ranging from minutes to hours, arriving in a so-called "internal wave train". Wave heights of tens of metres can be generated by large events. Although the impact of tsunamis is limited to coastal areas, their destructive power can be enormous, and they can affect entire ocean basins.

The 2004 Indian Ocean tsunami was among the deadliest natural disasters in human history, with at least 230,000 people killed or missing in 14 countries bordering the Indian Ocean.

The Ancient Greek historian Thucydides suggested in his 5th century BC *History of the Peloponnesian War* that tsunamis were related to submarine earthquakes, but the understanding of tsunamis remained slim until the 20th century and much remains unknown. Major areas of current research include determining why some large earthquakes do not generate tsunamis while other smaller ones do; accurately forecasting the passage of tsunamis across the oceans; and forecasting how tsunami waves interact with shorelines.

Terminology

Tsunami

The term "tsunami" is a borrowing from the Japanese *tsunami*, meaning "harbour wave". For the plural, one can either follow ordinary English practice and add an *s*, or use an invariable plural as in the Japanese. Some English speakers alter the word's initial /ts/ to an /s/ by dropping the "t", since English does not natively permit /ts/ at the beginning of words, though the original Japanese pronunciation is /ts/.

Tidal wave

Tsunamis are sometimes referred to as ***tidal waves***. This once-popular term derives from the most common appearance of a tsunami, which is that of an extraordinarily high tidal bore. Tsunamis and tides both produce waves of water that move inland, but in the case of a tsunami, the inland movement of water may be much greater, giving the impression of an incredibly high and forceful tide. In recent years, the term "tidal wave" has fallen out of favour, especially in the scientific community, because the causes of tsunamis have nothing to do with those of tides, which are produced by the gravitational pull of the moon and sun rather than the displacement of water. Although the meanings of "tidal" include "resembling" or "having the form or character of" the tides, use of the term *tidal wave* is discouraged by geologists and oceanographers.

A 1969 episode of the TV crime show *Hawaii Five-O* entitled "Forty Feet High And It Kills!" used the terms "tsunami" and "tidal wave" interchangeably.

Seismic sea wave

The term ***seismic sea wave*** also is used to refer to the phenomenon, because the waves most often are generated by seismic activity such as earthquakes. Prior to the rise of the use of the term *tsunami* in English, scientists generally encouraged the use of the term *seismic sea wave* rather than *tidal wave*. However, like *tsunami*, *seismic sea wave* is not a completely accurate term, as forces other than earthquakes – including underwater landslides, volcanic eruptions, underwater explosions, land or

ice slumping into the ocean, meteorite impacts, and the weather when the atmospheric pressure changes very rapidly – can generate such waves by displacing water.

History

While Japan may have the longest recorded history of tsunamis, the sheer destruction caused by the 2004 Indian Ocean earthquake and tsunami event mark it as the most devastating of its kind in modern times, killing around 230,000 people. The Sumatran region is also accustomed to tsunamis, with earthquakes of varying magnitudes regularly occurring off the coast of the island.

Tsunamis are an often underestimated hazard in the Mediterranean Sea and parts of Europe. Of historical and current (with regard to risk assumptions) importance are the 1755 Lisbon earthquake and tsunami (which was caused by the Azores–Gibraltar Transform Fault), the 1783 Calabrian earthquakes, each causing several tens of thousands of deaths and the 1908 Messina earthquake and tsunami. The tsunami claimed more than 123,000 lives in Sicily and Calabria and is among the most deadly natural disasters in modern Europe. The Storegga Slide in the Norwegian Sea and some examples of tsunamis affecting the British Isles refer to landslide and meteotsunamis predominantly and less to earthquake-induced waves.

As early as 426 BC the Greek historian Thucydides inquired in his book *History of the Peloponnesian War* about the causes of tsunami, and was the first to argue that ocean earthquakes must be the cause.

The cause, in my opinion, of this phenomenon must be sought in the earthquake. At the point where its shock has been the most violent the sea is driven back, and suddenly recoiling with redoubled force, causes the inundation. Without an earthquake I do not see how such an accident could happen.

The Roman historian Ammianus Marcellinus (*Res Gestae* 26.10.15–19) described the typical sequence of a tsunami, including an incipient earthquake, the sudden retreat of the sea and a following gigantic wave, after the 365 AD tsunami devastated Alexandria.

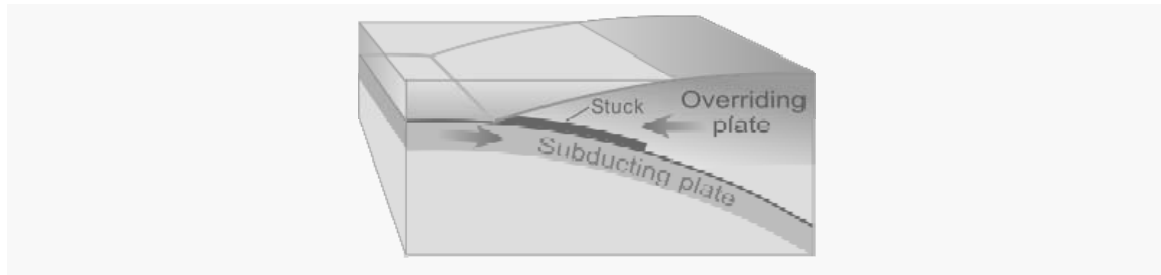
Causes

The principal generation mechanism (or cause) of a tsunami is the displacement of a substantial volume of water or perturbation of the sea. This displacement of water is usually attributed to either earthquakes, landslides, volcanic eruptions, glacier calvings or more rarely by meteorites and nuclear tests. The waves formed in this way are then sustained by gravity.

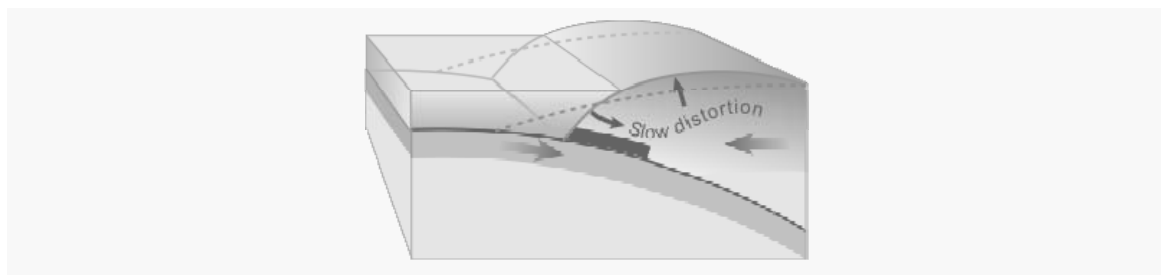
Seismicity

Tsunami can be generated when the sea floor abruptly deforms and vertically displaces the overlying water. Tectonic earthquakes are a particular kind of earthquake that are associated with the Earth's crustal deformation; when these earthquakes occur beneath the sea, the water above the deformed area is displaced from its equilibrium position. More specifically, a tsunami can be generated when thrust faults associated with convergent or destructive plate boundaries move abruptly, resulting in water

displacement, owing to the vertical component of movement involved. Movement on normal (extensional) faults can also cause displacement of the seabed, but only the largest of such events (typically related to flexure in the outer trench swell) cause enough displacement to give rise to a significant tsunami, such as the 1977 Sumba and 1933 Sanriku events.



Drawing of tectonic plate boundary before earthquake



Overriding plate bulges under strain, causing tectonic uplift.

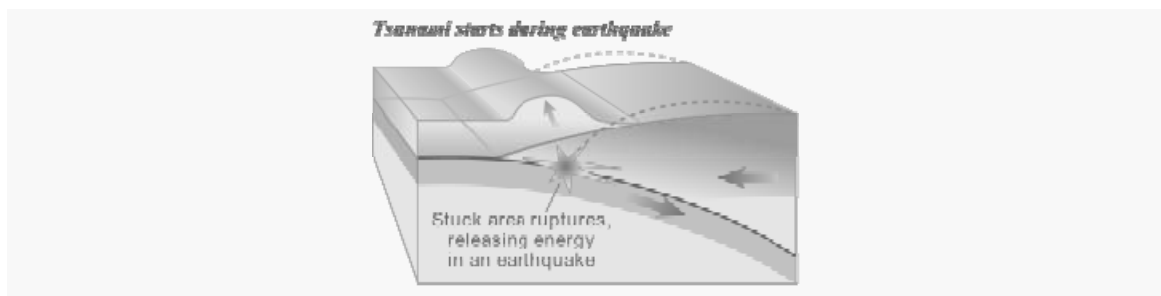
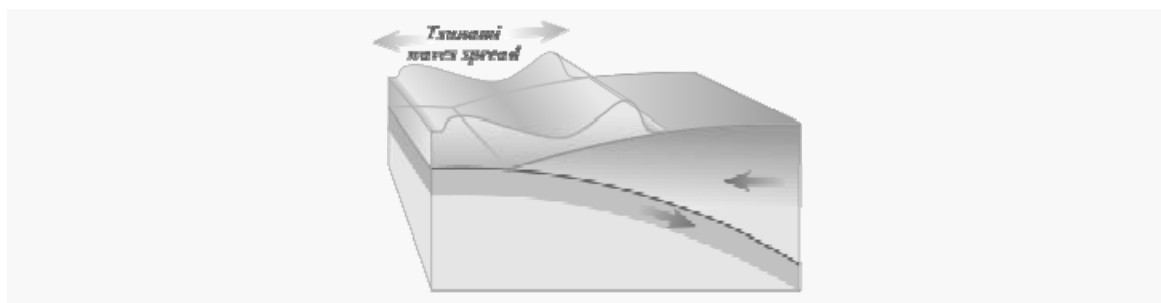


Plate slips, causing subsidence and releasing energy into water.



The energy released produces tsunami waves.

Tsunamis have a small amplitude (wave height) offshore, and a very long wavelength (often hundreds of kilometres long, whereas normal ocean waves have a wavelength of only 30 or 40 metres), which is why they generally pass unnoticed at sea, forming only a slight swell usually about 300 millimetres (12 in) above the normal sea surface. They grow in height when they reach shallower water, in a wave shoaling process described below. A tsunami can occur in any tidal state and even at low tide can still inundate coastal areas.

On April 1, 1946, the 8.6 M_w Aleutian Islands earthquake occurred with a maximum Mercalli intensity of VI (*Strong*). It generated a tsunami which inundated Hilo on the island of Hawaii with a 14-metre high (46 ft) surge. Between 165 and 173 were killed. The area where the earthquake occurred is where the Pacific Ocean floor is subducting (or being pushed downwards) under Alaska.

Examples of tsunami originating at locations away from convergent boundaries include Storegga about 8,000 years ago, Grand Banks 1929, Papua New Guinea 1998 (Tappin, 2001). The Grand Banks and Papua New Guinea tsunamis came from earthquakes which destabilised sediments, causing them to flow into the ocean and generate a tsunami. They dissipated before travelling transoceanic distances.

The cause of the Storegga sediment failure is unknown. Possibilities include an overloading of the sediments, an earthquake or a release of gas hydrates (methane etc.).

The 1960 Valdivia earthquake (M_w 9.5), 1964 Alaska earthquake (M_w 9.2), 2004 Indian Ocean earthquake (M_w 9.2), and 2011 Tōhoku earthquake (M_w 9.0) are recent examples of powerful megathrust earthquakes that generated tsunamis (known as teletsunamis) that can cross entire oceans. Smaller (M_w 4.2) earthquakes in Japan can trigger tsunamis (called **local** and **regional tsunamis**) that can devastate stretches of coastline, but can do so in only a few minutes at a time.

Landslides

In the 1950s, it was discovered that larger tsunamis than had previously been believed possible could be caused by giant submarine landslides. These rapidly displace large water volumes, as energy transfers to the water at a rate faster than the water can absorb. Their existence was confirmed in 1958, when a giant landslide in Lituya Bay, Alaska, caused the highest wave ever recorded, which had a height of 524 metres (over 1700 feet). The wave did not travel far, as it struck land almost immediately. Two people fishing in the bay were killed, but another boat managed to ride the wave.

Another landslide-tsunami event occurred in 1963 when a massive landslide from Monte Toc entered the Vajont Dam in Italy. The resulting wave surged over the 262 m (860 ft) high dam by 250 metres

(820 ft) and destroyed several towns. Around 2,000 people died. Scientists named these waves megatsunamis.

Some geologists claim that large landslides from volcanic islands, e.g. Cumbre Vieja on La Palma in the Canary Islands, may be able to generate megatsunamis that can cross oceans, but this is disputed by many others.

In general, landslides generate displacements mainly in the shallower parts of the coastline, and there is conjecture about the nature of large landslides that enter the water. This has been shown to subsequently affect water in enclosed bays and lakes, but a landslide large enough to cause a transoceanic tsunami has not occurred within recorded history. Susceptible locations are believed to be the Big Island of Hawaii, Fogo in the Cape Verde Islands, La Reunion in the Indian Ocean, and Cumbre Vieja on the island of La Palma in the Canary Islands; along with other volcanic ocean islands. This is because large masses of relatively unconsolidated volcanic material occurs on the flanks and in some cases detachment planes are believed to be developing. However, there is growing controversy about how dangerous these slopes actually are.

Meteorological

Some meteorological conditions, especially rapid changes in barometric pressure, as seen with the passing of a front, can displace bodies of water enough to cause trains of waves with wavelengths comparable to seismic tsunamis, but usually with lower energies. These are essentially dynamically equivalent to seismic tsunamis, the only differences being that meteotsunamis lack the transoceanic reach of significant seismic tsunamis and that the force that displaces the water is sustained over some length of time such that meteotsunamis can't be modelled as having been caused instantaneously. In spite of their lower energies, on shorelines where they can be amplified by resonance, they are sometimes powerful enough to cause localised damage and potential for loss of life. They have been documented in many places, including the Great Lakes, the Aegean Sea, the English Channel, and the Balearic Islands, where they are common enough to have a local name, *rissaga*. In Sicily they are called *marubbio* and in Nagasaki Bay, they are called *abiki*. Some examples of destructive meteotsunamis include 31 March 1979 at Nagasaki and 15 June 2006 at Menorca, the latter causing damage in the tens of millions of euros.

Meteotsunamis should not be confused with storm surges, which are local increases in sea level associated with the low barometric pressure of passing tropical cyclones, nor should they be confused with setup, the temporary local raising of sea level caused by strong on-shore winds. Storm surges and setup are also dangerous causes of coastal flooding in severe weather but their dynamics are completely unrelated to tsunami waves. They are unable to propagate beyond their sources, as waves do.

Man-made or triggered tsunamis

There have been studies of the potential of the induction of and at least one actual attempt to create tsunami waves as a tectonic weapon.

In World War II, the New Zealand Military Forces initiated Project Seal, which attempted to create small tsunamis with explosives in the area of today's Shakespear Regional Park; the attempt failed.

There has been considerable speculation on the possibility of using nuclear weapons to cause tsunamis near an enemy coastline. Even during World War II consideration of the idea using conventional explosives was explored. Nuclear testing in the Pacific Proving Ground by the United States seemed to generate poor results. *Operation Crossroads* fired two 20 kilotonnes of TNT (84 TJ) bombs, one in the air and one underwater, above and below the shallow (50 m (160 ft)) waters of the Bikini Atoll lagoon. Fired about 6 km (3.7 mi) from the nearest island, the waves there were no higher than 3–4 m (9.8–13.1 ft) upon reaching the shoreline. Other underwater tests, mainly *Hardtack I/Wahoo* (deep water) and *Hardtack I/Umbrella* (shallow water) confirmed the results. Analysis of the effects of shallow and deep underwater explosions indicate that the energy of the explosions doesn't easily generate the kind of deep, all-ocean waveforms which are tsunamis; most of the energy creates steam, causes vertical fountains above the water, and creates compressional waveforms. Tsunamis are hallmarked by permanent large vertical displacements of very large volumes of water which do not occur in explosions.

Characteristics

Tsunamis cause damage by two mechanisms: the smashing force of a wall of water travelling at high speed, and the destructive power of a large volume of water draining off the land and carrying a large amount of debris with it, even with waves that do not appear to be large.

While everyday wind waves have a wavelength (from crest to crest) of about 100 metres (330 ft) and a height of roughly 2 metres (6.6 ft), a tsunami in the deep ocean has a much larger wavelength of up to 200 kilometres (120 mi). Such a wave travels at well over 800 kilometres per hour (500 mph), but owing to the enormous wavelength the wave oscillation at any given point takes 20 or 30 minutes to complete a cycle and has an amplitude of only about 1 metre (3.3 ft). This makes tsunamis difficult to detect over deep water, where ships are unable to feel their passage.

The velocity of a tsunami can be calculated by obtaining the square root of the depth of the water in metres multiplied by the acceleration due to gravity (approximated to 10 m/s). For example, if the Pacific Ocean is considered to have a depth of 5000 metres, the velocity of a tsunami would be the square root of $\sqrt{(5000 \times 10)} = \sqrt{50000} = \sim 224$ metres per second (735 feet per second), which equates to a speed of ~ 806 kilometres per hour or about 500 miles per hour. This is the formula used for

calculating the velocity of shallow-water waves. Even the deep ocean is shallow in this sense because a tsunami wave is so long (horizontally from crest to crest) by comparison.

The reason for the Japanese name "harbour wave" is that sometimes a village's fishermen would sail out, and encounter no unusual waves while out at sea fishing, and come back to land to find their village devastated by a huge wave.

As the tsunami approaches the coast and the waters become shallow, wave shoaling compresses the wave and its speed decreases below 80 kilometres per hour (50 mph). Its wavelength diminishes to less than 20 kilometres (12 mi) and its amplitude grows enormously – in accord with Green's law. Since the wave still has the same very long period, the tsunami may take minutes to reach full height. Except for the very largest tsunamis, the approaching wave does not break, but rather appears like a fast-moving tidal bore. Open bays and coastlines adjacent to very deep water may shape the tsunami further into a step-like wave with a steep-breaking front.

When the tsunami's wave peak reaches the shore, the resulting temporary rise in sea level is termed *run up*. Run up is measured in metres above a reference sea level. A large tsunami may feature multiple waves arriving over a period of hours, with significant time between the wave crests. The first wave to reach the shore may not have the highest run-up.

About 80% of tsunamis occur in the Pacific Ocean, but they are possible wherever there are large bodies of water, including lakes. They are caused by earthquakes, landslides, volcanic explosions, glacier calvings, and bolides.

Drawbacks

All waves have a positive and negative peak; that is, a ridge and a trough. In the case of a propagating wave like a tsunami, either may be the first to arrive. If the first part to arrive at the shore is the ridge, a massive breaking wave or sudden flooding will be the first effect noticed on land. However, if the first part to arrive is a trough, a **drawback** will occur as the shoreline recedes dramatically, exposing normally submerged areas. The drawback can exceed hundreds of metres, and people unaware of the danger sometimes remain near the shore to satisfy their curiosity or to collect fish from the exposed seabed.

A typical wave period for a damaging tsunami is about twelve minutes. Thus, the sea recedes in the drawback phase, with areas well below sea level exposed after three minutes. For the next six minutes, the wave trough builds into a ridge which may flood the coast, and destruction ensues. During the next six minutes, the wave changes from a ridge to a trough, and the flood waters recede in a second drawback. Victims and debris may be swept into the ocean. The process repeats with succeeding waves.

Scale of intensity and magnitude

As with earthquakes, several attempts have been made to set up scales of tsunami intensity or magnitude to allow comparison between different events.

Intensity scales

The first scales used routinely to measure the intensity of tsunami were the *Sieberg-Ambraseys scale*, used in the Mediterranean Sea and the *Imamura-Iida intensity scale*, used in the Pacific Ocean. The latter scale was modified by Soloviev, who calculated the Tsunami intensity I according to the formula

$$I = \frac{1}{2} + \log_2 Hav$$

where Hav is the average wave height along the nearest coast. This scale, known as the *Soloviev-Imamura tsunami intensity scale*, is used in the global tsunami catalogues compiled by the NGDC/NOAA and the Novosibirsk Tsunami Laboratory as the main parameter for the size of the tsunami.

In 2013, following the intensively studied tsunamis in 2004 and 2011, a new 12-point scale was proposed, the Integrated Tsunami Intensity Scale (ITIS-2012), intended to match as closely as possible to the modified ESI2007 and EMS earthquake intensity scales.

Magnitude scales

The first scale that genuinely calculated a magnitude for a tsunami, rather than an intensity at a particular location was the ML scale proposed by Murty & Loomis based on the potential energy. Difficulties in calculating the potential energy of the tsunami mean that this scale is rarely used. Abe introduced the *tsunami magnitude scale*, M_t calculated from,

$$M_t = a \log h + b \log R = D$$

where h is the maximum tsunami-wave amplitude (in m) measured by a tide gauge at a distance R from the epicentre, a , b and D are constants used to make the M_t scale match as closely as possible with the moment magnitude scale.

Tsunami heights

Several terms are used to describe the different characteristics of tsunami in terms of their height:

- Amplitude, Wave Height, or Tsunami Height: Amplitude of Tsunami refers to its height relative to the normal sea level. It is usually measured at sea level, and it is different from the crest-to-trough height which is commonly used to measure other type of wave height.

- Run-up Height, or Inundation Height: The height reached by a tsunami on the ground above sea level, Maximum run-up height refers to the maximum height reached by water above sea level, which is sometimes reported as the maximum height reached by a tsunami.
- Flow Depth: Refers to the height of tsunami above ground, regardless of the height of the location or sea level.
- (Maximum) Water Level: Maximum height above sea level as seen from trace or water mark. Different from maximum run-up height in the sense that they are not necessarily water marks at inundation line/limit.

Warning and Predictions

Drawbacks can serve as a brief warning. People who observe drawback (many survivors report an accompanying sucking sound), can survive only if they immediately run for high ground or seek the upper floors of nearby buildings. In 2004, ten-year-old Tilly Smith of Surrey, England, was on Maikhao beach in Phuket, Thailand with her parents and sister, and having learned about tsunamis recently in school, told her family that a tsunami might be imminent. Her parents warned others minutes before the wave arrived, saving dozens of lives. She credited her geography teacher, Andrew Kearney.

In the 2004 Indian Ocean tsunami drawback was not reported on the African coast or any other east-facing coasts that it reached. This was because the wave moved downwards on the eastern side of the fault line and upwards on the western side. The western pulse hit coastal Africa and other western areas.

A tsunami cannot be precisely predicted, even if the magnitude and location of an earthquake is known. Geologists, oceanographers, and seismologists analyse each earthquake and based on many factors may or may not issue a tsunami warning. However, there are some warning signs of an impending tsunami, and automated systems can provide warnings immediately after an earthquake in time to save lives. One of the most successful systems uses bottom pressure sensors, attached to buoys, which constantly monitor the pressure of the overlying water column.

Regions with a high tsunami risk typically use tsunami warning systems to warn the population before the wave reaches land. On the west coast of the United States, which is prone to Pacific Ocean tsunami, warning signs indicate evacuation routes. In Japan, the community is well-educated about earthquakes and tsunamis, and along the Japanese shorelines the tsunami warning signs are reminders of the natural hazards together with a network of warning sirens, typically at the top of the cliff of surroundings hills.

The Pacific Tsunami Warning System is based in Honolulu, Hawai'i. It monitors Pacific Ocean seismic activity. A sufficiently large earthquake magnitude and other information triggers a tsunami warning. While the subduction zones around the Pacific are seismically active, not all earthquakes

generate a tsunami. Computers assist in analysing the tsunami risk of every earthquake that occurs in the Pacific Ocean and the adjoining land masses.

Computer models can predict tsunami arrival, usually within minutes of the arrival time. Bottom pressure sensors can relay information in real time. Based on these pressure readings and other seismic information and the seafloor's shape (bathymetry) and coastal topography, the models estimate the amplitude and surge height of the approaching tsunami. All Pacific Rim countries collaborate in the Tsunami Warning System and most regularly practise evacuation and other procedures. In Japan, such preparation is mandatory for government, local authorities, emergency services and the population.

Some zoologists hypothesise that some animal species have an ability to sense subsonic Rayleigh waves from an earthquake or a tsunami. If correct, monitoring their behaviour could provide advance warning of earthquakes, tsunami etc. However, the evidence is controversial and is not widely accepted. There are unsubstantiated claims about the Lisbon quake that some animals escaped to higher ground, while many other animals in the same areas drowned. The phenomenon was also noted by media sources in Sri Lanka in the 2004 Indian Ocean earthquake. It is possible that certain animals (e.g., elephants) may have heard the sounds of the tsunami as it approached the coast. The elephants' reaction was to move away from the approaching noise. By contrast, some humans went to the shore to investigate and many drowned as a result.

Along the United States west coast, in addition to sirens, warnings are sent on television and radio via the National Weather Service, using the Emergency Alert System.

Forecast of tsunami attack probability

Kunihiko Shimazaki (University of Tokyo), a leading member of the Earthquake Research Committee at The Headquarters for Earthquake Research Promotion in Japan, has mentioned an idea for instituting a system of public education regarding the probability of tsunami risk; such a system was announced by Shimazaki at the Japan National Press Club in May 2011. The forecast would include a detection for environmental risk, including proposed tsunami height, danger areas prone to tsunamis, and overall occurrence probability. The forecast would integrate the scientific knowledge of recent interdisciplinarity with information gathered from the aftermath of the 2011 Tōhoku earthquake and tsunami. Per the announcement, a plan was due to be put in place by 2014; however, reliable forecasting of earthquake and tsunami probability is still unavailable. Shimazaki acknowledged that, given the current literature on the topic, tsunami probability warnings are just as, if not more, difficult to predict than earthquake risk probability.

Mitigation

In some tsunami-prone countries, earthquake engineering measures have been taken to reduce the damage caused onshore.

Japan, where tsunami science and response measures first began following a disaster in 1896, has produced ever-more elaborate countermeasures and response plans. The country has built many tsunami walls of up to 12 metres (39 ft) high to protect populated coastal areas. Other localities have built floodgates of up to 15.5 metres (51 ft) high and channels to redirect the water from an incoming tsunami. However, their effectiveness has been questioned, as tsunami often overtop the barriers.

The Fukushima Daiichi nuclear disaster was directly triggered by the 2011 Tōhoku earthquake and tsunami, when waves exceeded the height of the plant's sea wall. Iwate Prefecture, which is an area at high risk from tsunami, had tsunami barriers walls (Taro sea wall) totalling 25 kilometres (16 mi) long at coastal towns. The 2011 tsunami toppled more than 50% of the walls and caused catastrophic damage.

The Okushiri, Hokkaidō tsunami which struck Okushiri Island of Hokkaidō within two to five minutes of the earthquake on July 12, 1993, created waves as much as 30 metres (100 ft) tall—as high as a 10-storey building. The port town of Aomae was completely surrounded by a tsunami wall, but the waves washed right over the wall and destroyed all the wood-framed structures in the area. The wall may have succeeded in slowing down and moderating the height of the tsunami, but it did not prevent major destruction and loss of life (Tsunami).

UNIT-14: HYDROLOGICAL HAZARDS: FLASH FLOODS IN HIMALAYAN REGION AND FLOODS IN SOUTHERN PART OF WEST BENGAL

Understanding Risk from Floods in the Himalayan Region

The State of Uttarakhand, the worst affected region of north India has a total area of 53,484 sq. km, of which 93% is mountainous and 64% is forest. The four very important and ancient temples are located in this region where pilgrims/tourists travel every year during summer months when roads become accessible (Yadav and Sahani 2013). During June 14-17, 2013, a weather system that has a very low likelihood caused heavy torrential rains over a few days. This rainfall resulted in extensive flooding and landslides in the region that is geologically sensitive due to its geographic location in the Himalayan mountain range. According to the Meteorological Departments of India and Pakistan, the monsoon advancing towards the west of South Asia, combined with westerly winds resulted in several days of torrential rains. The weather interaction of this kind normally occurs between October and April, but extended to June. The intensity was also much higher than normally seen (Nirupama et al. 2014). The destruction in terms of thousands of lives lost, millions of dollars (US\$) lost in damage, and thousands of pilgrims gone missing was sufficient to encourage the public and the authorities to engage in understanding risks and potential mitigation measures to prevent a similar event from reoccurring in the future. This paper is intended to enhance our understanding of risk and

vulnerability in the region and approaches to build resilience in communities. Table 1: district-wise rainfall distribution from June 13-19, 2013 (SANDRP 2013).

District	Actual rainfall (mm)	Normal rainfall (mm)	% Departure
Almora	208.7	26.3	694
Bageshwar	391.2	26.3	1387
Chamoli	316.9	22.6	1302
Champawat	351	33.5	948
Dehradun	565.4	36.8	1436
Garhwal Pauri	149.7	15.8	847
Garhwal Tehri	327.7	22	1390
Hardwar	298.8	21.6	1283
Nainital	506.5	38.8	1205
Pithoragarh	246.9	73	238
Rudraprayag	366.3	53.9	580
Udham Singh Nagar	157.7	40.2	292
Uttarkashi	375.6	25.8	1356

The Case Study

A combination of heavy rainfall, glacial melt, landslides, and resulting debris flow wreak havoc in the Himalayan mountainous region. A global sweep of westerlies triggered severe flooding across central Europe (leaving a trail of deadly flooding in Germany, Austria and the Czech Republic) and collided with the south-west monsoon over north India, causing the deadliest rains in decades (Fig. 2). Meteorologists investigating the factors behind the devastation said although such extreme weather events were not uncommon in Himalayan regions such as Uttarakhand, the monsoon could not have, on its own, resulted in heavy rainfall (Haq 2013; Krishnan 2013).

Although in July 1968 in Rajasthan and Gujarat States of India, a similar event occurred in which nearly 5000 people died (CWC 2013), it is a very low probability event. While cloud burst is due to natural causes, the flooding and landslides are due to a combination of natural causes and human

induced factors such as deforestation, urbanization, and misguided landuse. Although there are no raingauges at the four main temples, Kedarnath, Badrinath, Gangotri, and Yamunotri where pilgrims/tourists suffered the most, the nearest raingauge stations in various districts in the region provide valuable data as shown in Table 1. Figure 2 shows the precipitation scenario during June 11-17, 2013. Since 1950, 17 major flood disasters have killed more than 1,000 people in each event in India (EMDAT 2013); and about 60,000 people were killed due to monsoon related floods during 1950-2012 (UWI 2013; CWC 2013; IMD 2013). The June 2013 monsoon rains came to the region two weeks earlier than normal with the fastest progression of the monsoon on record. This meant that the more than 340 millimetres of rainfall (normal rainfall being about 66 mm) coincided with the pilgrimage season in the region. Some areas experienced the wettest season in over 50 years. To make matters worse, there was snow on the ground, therefore, heavy rainfall combined with the snow created suitable conditions for landslides in the affected region (SANDRP 2013; Ramachandran 2013; Bagla 2013; Climate Himalaya 2013). Figure 3 shows widespread damage before and after the disaster.

The famous Kedarnath Hindu shrine, located just a short distance from the snout of two mountain glaciers was hit by a massive 75 m wide landslide. The shrine being one of the most important pilgrimage destination was packed with devotees celebrating a religious holiday (Dobhal et al. 2013; Krishnan 2013). The debris flow gained enormous speed due to the steep slope in the area.

Understanding Risk and Vulnerability

Hazard risk can be defined as a product of hazard likelihood, exposure to the hazard, and vulnerability (Smith and Petley 2009; Armenakis and Nirupama 2013). The event in this paper can be described as a combination of heavy rainfall, flooding, and landslides for which the severity of impact was enormous (Theophilus 2013; Sphere India 2013; NDMA 2013; DMMC 2013).

Historical data of past similar rainfall events in the same area has been examined in order to establish a likelihood using the records of the India Meteorological Department (IMD 2013). The last time a cloud burst of a similar magnitude happened was on July 25, 1966 in the same area, which is about 48 years ago. In rough terms, we can treat this as a 50 year return period, which ties in well with the analysis we did above for the impact.

In order to better understand vulnerability of people and infrastructure as well as exposure to the hazard, social, economic, infrastructural, and environmental factors have been taken into account in this study. Social impact was felt by communities that lost nearly 6,000 people, found over a million tourists stranded/evacuated, and lost account of thousands of missing persons. The total number of affected persons is estimated as an astonishing 1.6 million (UWI 2013). Over 15,700 villages suffered destruction covering an estimated area of 96,000 sq. km. At the time of tragedy, about 30 million tourists/pilgrims were present in the region. Figures 5-6 show the pre and post disaster scene of the area. Economic impact became evident when thousands of livestock were found dead, illegal housing

on riverbeds were discovered and reported, and thousands of illegal mining sites were uncovered, notified, and stopped in the region. Close to USD 500 million were lost in damages – most of which was uninsured. Environmentally, there were water contamination concerns, millions of dollars lost in forest damage and loss of flora and fauna in this extremely ecologically valuable and sensitive region. Critical facilities and essential services were severely crippled by the shortage of medicines and drinking water in hundreds of villages. Critical infrastructure, such as important bridges (Fig. 6), roads connecting remotely located villages, water distribution and hydroelectric plants, and power lines were critically compromised and damaged. Estimates suggest (UWI 2013) that 695 water schemes were affected and over a thousand bridges were damaged. Greed, ignorance, and misplaced priorities have contributed to deforestation, illegal mining, and unplanned development in the region (Fig. 7). Commercial deforestation in the Himalayas has been going on despite government's claim of forest cover increasing (Yadav and Sahani 2013). India has been growing about twelve times per century but it would be unwise to increase existing and create new social and environmental vulnerabilities in this process. With the current economic growth in the country, the infrastructure has gone up exponentially and in most cases safety standards have been ignored.

Conclusions

Four ancient holy sites of Uttarakhand (Kedarnath, Badrinath, Gangotri, and Yamnotri) in northern Himalayan region of India that are visited by millions of Hindu pilgrims and tourists every year were in the impact area. If there is another event in the future that is similar to this one, the potential impact could be ten times as compared to the June 2013 event. A multifaceted event that is not uncommon in the era of ever developing urban and rural regions in developing countries. Changing natural environment and human interactions with it needs to be addressed in order to bring meaningful awareness among stakeholders. A challenging aspect of the particular event discussed here is that it crosses administrative boundaries which makes it difficult to prepare for potential risk and respond to the disaster. Every summer season (May-August) millions of religious devotees participate in the pilgrimage to the difficult Himalayan terrain, therefore, it is important that resilience building in communities and institutions is taken seriously. Identification of unsafe locations and conditions and assessment of risk and vulnerability is a vital first step toward mitigation of future disasters. Mitigation measures should address improving of roads and tourist accommodations, reducing soil erosion in the hilly terrain, and regularly monitoring rainfall and river flows in the area. Feasibility of these mitigation options needs to be discussed with communities for their understanding and consent as well (Understanding Risk from Floods and Landslides in the Himalayan Region: A Discussion to Enhance Resilience).

Flood

A flood is an overflow of an expanse of water that submerges land. The EU Floods directive defines a flood as a temporary covering by water of land not normally covered by water. In the sense of "flowing water", the word may also be applied to the inflow of the tide. Flooding may result from the

volume of water within a body of water, such as a river or lake, which overflows or breaks levees, with the result that some of the water escapes its usual boundaries. While the size of a lake or other body of water will vary with seasonal changes in precipitation and snow melt, it is not a significant flood unless the water covers land used by man like a village, city or other inhabited area, roads, expanses of farmland, etc. River and coastal flooding are the most frequently occurring natural disaster and are increasing in occurrence more rapidly than any other disaster. Urbanization and deforestation reduce the capability of the earth to hold excess water. As asphalt- and concrete-covered surfaces expand and open spaces disappear at the edges of metropolitan areas, it takes less rain to flood communities as water running over the pavement collects quickly and easily disrupts storm drain systems. Those areas which are most at risk for floods include low-lying areas, coastal regions, and communities on rivers downstream from dams. Flood waters are extremely dangerous; a mere six inches of swiftly moving water can knock people off their feet. In some places flooding is caused by excessive monsoons, while in others flooding is caused downstream from dams when reservoirs, which normally help to prevent downstream areas of rivers from flooding, are opened due to unusually high levels of rain to prevent the reservoir from overflowing the dam. Dam breaks are also a cause of catastrophic flooding. West Bengal has 37,660 sq. km flood prone area spread over 111 blocks where the total geographical area of the state is 88,752 sq. km. An analysis of the statistics of flood that occurred during last 41 years (from 1960 - 2000) shows that only on 5 occasions the state has not faced any severe flood. The total devastated area crossed 20,000 sq. km in 4 different years and the flood of medium magnitude i.e. between 2,000 to 10,000 sq. km. occurred on 10 occasions.

The Flood Problem

The flood problems of the state are of different nature at different regions. The rivers Teesta, Torsa, Jaldhaka, Raidak-I, Raidak-II etc. flowing through the districts of Jalpaiguri and Cooch Behar originate in the neighbouring country of Bhutan and the state of Sikkim and flows down to Bangladesh, another neighbouring country to meet the Brahmaputra at different locations. The rivers of the districts of Uttar Dinajpur and Dakshin Dinajpur originating at Bangladesh passes through these districts and then joins the Ganga-Padma at downstream of Farakka in Bangladesh. Both the places of origin and also the outfall of most of these rivers are in Bangladesh. The district of Malda through which the river Ganga flows receives its flood water from about 11 (eleven) States and is battered by the run-off flow generated from these vast areas. Ultimately the river flows down the Farakka Barrage to Bangladesh. Another portion of the Malda district receives floodwaters of the Mahananda, which again originates in the hills of the neighbouring country of Nepal and has some catchment area in the neighbouring state of Bihar and then passes through the district to join the Ganga-Padma at downstream of Farakka Barrage in Bangladesh. Major contributing factors to flood in North Bengal regions are the run-off because of heavy local rainfall, discharge of upper basin areas and also outfall condition in the neighbouring countries. The Mahananda and most of the rivers of Uttar and Dakshin Dinajpur districts get stagnated when the Ganga upstream and downstream of Farakka Barrage rules high thereby not allowing drainage of flood discharge during that period.

Analysis of Area Flooded against Years of Occurrence

Flood affected area (in sq. km)	Years during which the flood occurred	Total No. of years
Below 500	1985, 89, 92, 94 & 97	5
Between 500 - 2000	1962, 63, 64, 65, 66, 72, 75 & 96	8
2000 – 5000	1960, 61, 67, 69, 70, 74, 76, 80, 81 & 82	10
5000 – 10000	1973, 77, 93, 95 & 98	5
10000 – 15000	1968, 79, 83, 90 & 99	5
15000 – 20000	1971, 86, 87 & 88	4
Above 20000	1978, 84, 91 & 2000	4

Occurrence of Flood

Flood	North Bengal	South Bengal
Districts Affected by Flood	Cooch Behar, Jalpaiguri, Uttar Dinajpur, Dakshin Dinajpur, Malda;	Nadia, Howrah, Murshidabad, North 24 Parganas, South 24 Parganas, Hooghly, Burdwan, Birbhum, Paschim Medinipur, Purba Medinipur
Relatively scare Districts affected by Flood	Darjeeling	Puruliya & Bankura

Types of Flood

It is a temporary inundation of large regions as a result of an increase in reservoir, or of rivers flooding their banks because of heavy rains, high winds, cyclones storm surge along coast, tsunami, melting snow or dam bursts.

Flash Floods

It is defined as floods which occur within six hours of the beginning of heavy rainfall, and are usually associated with cloud bursts, storms and cyclones requiring rapid localized warning and immediate response if damage is to be mitigated. In case of flash floods, warning for timely evacuation may not always be possible.

River Floods

Such floods are caused by precipitation over large catchment's areas. These floods normally build up slowly or seasonally and may continue for days or weeks as compared to flash floods.

Coastal Floods

Some floods are associated with the cyclonic activities like Hurricanes, tropical cyclone etc. Catastrophic flooding is often aggravated by wind-induced storm surges along the coast.

River System in West Bengal

The Ganga-Padma river artery divides the state in two parts, north and south. Being a part of Ganga-Bhramhputra-Meghna basin, North Bengal is extremely flood prone. The rivers Teesta, Torsa, Jaldhaka, Raidak-I, Raidak-II and their numerous tributaries belonging to the Brammhaputra basin and flowing through a part of Darjeeling, Jalpaiguri and Coochbehar originate in the Himalayas of Sikkim and Bhutan and flows south-east to Bangladesh. A part of Darjeeling and the districts of Uttar Dinajpur, Dakshin Dinajpur and Malda are drained through the rivers of Mahananda, Dauk, Tangon, Nagar, Atreyee, Punarbhaba and their tributaries. These are part of Ganga basin. Except the Mahananda, all other rivers originate in the plain of West Bengal and Bangladesh and join the Ganga-Padma at downstream of Farakka in Bangladesh. The Mahananda emerges from the Nepal Himalayas. Malda through which the river Ganga Flows receives its flood water from about eleven states and batters by the run-off flow generated from these vast areas. In central and southern part of this state, there are certain distinctive features of drainage condition which gives rise to flood situation. Basin-wise there are a number of rivers on the right bank of the Bhagirathi-Hoogly. These are Pagla-Bansloi, the Dwarka-Bramhani, the Mayurakshi-Babla- Uttarasan, the Bakreswar-Kuye and also the Ajoy. They emerge from the Jharkhand Plateau and flow southeast to meet Bhagirathi-Hoogly. These rivers drain an area of 17,684 km. spread over the State Jharkhand and Birbhum, western part of Murshidabad and Burdwan. Originating from Ganga-Padma, the Bhairab-Jalangi-Sealmari system of rivers drain the eastern part of Murshidabad and meet the Bhagirathi at Swarupnagar in Nadia. Nadia is drained partly by Jalangi and partly by the Churni which is a part of Mathabhanga-Churni- Ichamati system, taking off from Ganga-Padma flowing southwest, to meet Bhagirathi on the east bank at Ranaghat. The other part viz. the Ichamati flows east through Bangladesh enters the district of Uttar 24 Paraganas, flows in the south direction to fall into the tidal creek of the Raimangal. Part of Howrah and Uttar and Dakshin 24 Paraganas are drained mainly by the Hoogly and its tidal creeks and other internal drainage canals. Burdwan, Howrah and Hoogly districts are mainly drained by Damodar and Bhagirathi-Hoogly Rivers. In the Damodar-Barakar basin system, the rivers originate at Chotanagpur plateau and flow down the plains of West Bengal to meet Bhagirathi. The Ajoy forms the border between Birbhum and Burdwan. Purulia and Bankura are drained by the rivers of Kangsabati,

Kumari, Shilabati, Keleghai, Dwarakeswar and their tributaries. The Keleghai also drains Paschim Medinipur and a part of Purba Medinipur. These rivers originate from the western highland of the state and flow in southeast direction to form the tidal rivers of the Rupnarayan and the Haldi to meet the Hoogly on the west bank. The Rupnarayan forms the boundary between Hoogly and Purba Medinipur. A part of Purba Medinipur is drained by the river Subarnarekha originating from the Jharkhand Plateau and flowing in southwest direction to meet the Bay of Bengal in Orissa.

Causes of Flood

- (i)** Excessive rainfall in river catchments or concentration of runoff from the tributaries and river carrying flows in excess of their capacities.
- (ii)** Backing of water in tributaries at their confluence with the main river.
- (iii)** Synchronization of flood peaks of the main rivers and tributaries.
- (iv)** Landslides causing obstruction to flow and change in the river course.
- (v)** Poor natural drainage.
- (vi)** Cyclone and very intense rainfall.
- (vii)** Intense rainfall when river is flowing full.

The floods of West Bengal have special characteristics. Heavy rainfall at origin or catchment's areas of main flooding rivers of this state cause flood, but these areas are mainly lying outside this state. The West Bengal is flooded by water from adjoining states or countries. Major contributing factors to flood in Northern regions are the run-off because of heavy local rainfall, discharge of upper basin areas and also out fall condition in the neighbouring countries. The Mahananda and most of the rivers of Uttar and Dakshin Dinajpur districts get stagnated when the Ganga upstream and downstream of Farakka Barrage runs high there by not allowing draining of flood discharge during that period. Flooding Malda is caused by the rivers Fulhar-Mahananda and Ganga. The Ganga, forming the southern boundary of the district, brings flood water from eleven states and Nepal. The Fulhar meets the Ganga upstream of Farakka. The rivers of Bhagirathi-Hoogly basin generate flood because of high rainfall and limited carrying capacity of the river Bhagirathi from Jangipur in Murshidabad to Kalna in Bardwan. In this reach the Bhagirathi has discharge carrying capacity of maximum 1.3 lac. Cusec. But all these rivers if receive rainfall simultaneously in their catchment areas can generate run-off volume of any amount between 4-6 lac. Cusec. In this vast tract of land there is only the Massanjore dam to interfere with the natural flow of flood water. The basic reason of flood in this zone is the shape of the catchment area, its steep slope from a high level plateau area sloping sharply down to a flat terrain near the outfall and also adverse outfall condition because of its

limited intake capacity. This feature is again adversely affected by the tidal condition as is generally noticed in the month of September, when the Hoogly is in high tide condition. Delay in drainage causes more accumulation resulting in spread of flood in the upstream of the river system in the west and beyond Berhampur. Generally part of Murshidabad and Nadia suffer from flood because of three reasons –

(1) High intensity rainfall in the basin area of Bhairabi-Jalangi-Sealmari itself,

(2) Inflow of flood water from Ganga-Padma at its high spate and

(3) Drainage congestion at its outfall because of the high stage of Bhagirathi.

Traditionally, Damodar basin was known to be a curse. The basin of river Damodar has a very special shape and this influences its flood pattern. The river has about 70% of its basin just upstream of Durgapur town. This upper catchments of Jharkhand plateau, above Durgapur, generates heavy run-off during high rainfall and is carried to Durgapur in a short time. From here, this discharge travels through the river, bifurcating at Beguahana. One branch, the lower Damodar with very small capacity, reaches the Hoogly on the west bank. The major discharge passes through the Mundeswari to meet the Rupnarayan. Any major discharge along the downstream of Durgapur Barrage may cause flood depending upon the outfall condition of the Mundeswari at Harinkhola. In Kangsabati river system, the Kangsabati Dam has a limited flood storage capacity which is very nominal. Any major spillway discharge from Kangsabati Dam may cause flood at lower areas downstream of Medinipur town depending on tide and downstream rainfall. Flood Among natural hazards, occurrence of flood ranks first in West Bengal which has become annual festival in the State. Almost all the districts are affected by flood from July to October. But flood is relatively scarce in Darjeeling in North Bengal and Bankura & Purulia in South Bengal. The detail is depicted in the following matrix. According to the Irrigation Department, 37.6 lakhs Ha of West Bengal (42.4% of the total geographical area and 69% of its net cropped area) has been identified as flood prone area; of this 29.8 lakh Ha (i.e., 58% of

the flood prone area) is Protected Area. Strong monsoon, rivers and floods are an integral part of Bengal's characteristic ecology that shaped its civilization and culture and at the same time, cause of flood hazard and disasters for the society as a whole. Almost all the districts are affected by flood from July to October. But flood is relatively scarce in Darjeeling in North Bengal and Bankura & Purulia in South Bengal. The detail is depicted in the following matrix. According to the Irrigation Department, 37.6 lakhs Ha of West Bengal (42.4% of the total geographical area and 69% of its net cropped area) has been identified as flood prone area; of this 29.8 lakh Ha (i.e., 58% of the flood prone area) is Protected Area. Strong monsoon, rivers and floods are an integral part of Bengal's characteristic ecology that shaped its civilization and culture and at the same time, cause of flood hazard and disasters for the society as a whole.

Records of Large Floods in West Bengal

Period	Description
1978	Major Flood
1986	Flooding due to heavy rains in some areas of Kolkata, Hooghly, Howrah, Parganas and Midnapore
1988	Monsoonal rains caused flooding in areas of Balurghat and Dinajpur lying under the purview of the Ganges and Churani rivers
1991	Flash floods caused damage 35,000 houses
1995	Flooding triggered by heavy rains caused erosion, severe agricultural damage and outbreak of diseases
1998	Monsoon rains caused flooding of the Ganges River
1999	Tropical cyclones caused destruction of an estimated number of 1500 villages. Floods due to brief torrential rains affected areas of Kolkata, Burdwan and Birbhum
2000	Besides flash floods triggered by incessant torrential rains, disaster is also accredited to the opening of sluice gates of dams. The fatalities counted to the tune of 1262, besides affecting millions of people.
2002	Flooding in Jalpaiguri, Cooch Behar and Jalpaiguri in north Bengal due to monsoonal rains. Flash floods swamped ten villages, causing four deaths and 11,000 displacements
2003	Monsoonal rains caused floods affecting the regions of Darjeeling, Jalpaiguri, Malda and Murshidabad
2004	Heavy monsoonal rains affected several districts
2005	Heavy rains caused floods in many areas. About 3000 coastal villages were inundated and 60,000 huts and many roads washed away.
2005	Heavy rains caused floods in many areas. About 3000 coastal villages were inundated and 60,000 huts and many roads washed away. Heavy monsoon rains triggered flash floods and landslides
2006	The regions of Birbhum, Burdwan and Murshidabad were affected mainly from continuous monsoonal downpour Monsoonal rains and tropical cyclone-driven storms in the Bay of Bengal hit India and Bangladesh. West Bengal recorded 50 deaths, 300 were injured and

	30,000 mud houses destroyed. Heavy rains left large parts of Kolkata city under water; subsequently 2000 people were evacuated from the city.
2007	Heavy rain from tropical depression in the Bay of Bengal caused flooding leading to 51 deaths, and affecting 3.2 million people.
2013	Heavy rainfall & water release from various dams by DVC led to widespread flooding in the districts of Paschim & Purba Medinipur, Howrah, Hooghly, Bardhaman and Bankura Causing 17 deaths, 8790 villages affected, and affecting 2.1 million people

Elements at Risk

Anything in the flood plains will get inundated. building built of earth, weak foundations, and soluble materials will collapse endangering humans and their property. Basements of buildings are under risk. Utilities such as sewerage, water supply, communication lines, and power are put at risk. Food stock in the godowns, agricultural fields, livestock, vehicles, machinery and equipments mounted on the ground, fishing boats are also put at risk (Flood).

UNIT-15: SOURCES, IMPACTS AND MITIGATION MEASURES OF NUCLEAR HAZARD AND RADIO-ACTIVE CONTAMINATION, CFC AND PLASTIC HAZARD

Radioactive contamination, also called **radiological contamination**, is the deposition of, or presence of radioactive substances on surfaces or within solids, liquids or gases (including the human body), where their presence is unintended or undesirable (from the International Atomic Energy Agency – IAEA – definition).

Such contamination presents a hazard because of the radioactive decay of the contaminants, which emit harmful ionising radiation such as alpha particles or beta particles, gamma rays or neutrons. The degree of hazard is determined by the concentration of the contaminants, the energy of the radiation being emitted, the type of radiation, and the proximity of the contamination to organs of the body. It is important to be clear that the contamination gives rise to the radiation hazard, and the terms "radiation" and "contamination" are not interchangeable.

Contamination may affect a person, a place, an animal, or an object such as clothing. Following an atmospheric nuclear weapon discharge or a nuclear reactor containment breach, the air, soil, people, plants, and animals in the vicinity will become contaminated by nuclear fuel and fission products. A spilled vial of radioactive material like uranyl nitrate may contaminate the floor and any rags used to wipe up the spill. Cases of widespread radioactive contamination include the Bikini Atoll, the Rocky

Flats Plant in Colorado, the Fukushima Daiichi nuclear disaster, the Chernobyl disaster, and the area around the Mayak facility in Russia.

Sources of contamination

Radioactive contamination can be due to a variety of causes. It may occur due to release of radioactive gases, liquids or particles. For example, if a radionuclide used in nuclear medicine is spilled (accidentally or, as in the case of the Goiânia accident, through ignorance), the material could be spread by people as they walk around.

Radioactive contamination may also be an inevitable result of certain processes, such as the release of radioactive xenon in nuclear fuel reprocessing. In cases that radioactive material cannot be contained, it may be diluted to safe concentrations. For a discussion of environmental contamination by alpha emitters please see actinides in the environment.

Nuclear fallout is the distribution of radioactive contamination by the 520 atmospheric nuclear explosions that took place from the 1950s to the 1980s.

In nuclear accidents, a measure of the type and amount of radioactivity released, such as from a reactor containment failure, is known as the source term. The United States Nuclear Regulatory Commission defines this as "Types and amounts of radioactive or hazardous material released to the environment following an accident."

Contamination does not include residual radioactive material remaining at a site after the completion of decommissioning. Therefore, radioactive material in sealed and designated containers is not properly referred to as contamination, although the units of measurement might be the same.

Containment

Containment is the primary way of preventing contamination being released into the environment or coming into contact or being ingested by humans.

Being within the intended Containment differentiates radioactive *material* from radioactive *contamination*. When radioactive materials are concentrated to a detectable level outside containment, the area affected is generally referred to as "contaminated".

There are a large number of techniques for containing radioactive materials so that it does not spread beyond the containment and become contamination. In the case of liquids this is by the use of high integrity tanks or containers, usually with a sump system so that leakage can be detected by radiometric or conventional instrumentation.

Where material is likely to become airborne, then extensive use is made of the glovebox, which is a common technique in hazardous laboratory and process operations in many industries. The glove

boxes are kept under a slight negative pressure and the vent gas is filtered in high efficiency filters, which are monitored by radiological instrumentation to ensure they are functioning correctly.

Naturally occurring radioactivity

A variety of radio nuclides occur naturally in the environment. Elements like uranium and thorium, and their decay products, are present in rock and soil. Potassium-40, a primordial nuclide, makes up a small percentage of all potassium and is present in the human body. Other nuclides, like carbon-14, which is present in all living organisms, are continuously created by cosmic rays.

These levels of radioactivity pose little danger but can confuse measurement. A particular problem is encountered with naturally generated radon gas which can affect instruments which are set to detect contamination close to normal background levels and can cause false alarms. Because of this skill is required by the operator of radiological survey equipment to differentiate between background radiation and the radiation which emanates from contamination.

Naturally occurring radioactive materials (NORM) can be brought to the surface or concentrated by human activities like mining, oil and gas extraction and coal consumption.

Control and monitoring of contamination

Radioactive contamination may exist on surfaces or in volumes of material or air, and specialist techniques are used to measure the levels of contamination by detection of the emitted radiation.

Contamination monitoring

Contamination monitoring depends entirely upon the correct and appropriate deployment and utilisation of radiation monitoring instruments.

Surface contamination

Surface contamination may either be fixed or "free". In the case of fixed contamination, the radioactive material cannot by definition be spread, but its radiation is still measurable. In the case of free contamination there is the hazard of contamination spread to other surfaces such as skin or clothing, or entrainment in the air. A concrete surface contaminated by radioactivity can be shaved to a specific depth, removing the contaminated material for disposal.

For occupational workers controlled areas are established where there may be a contamination hazard. Access to such areas is controlled by a variety of barrier techniques, sometimes involving changes of clothing and foot wear as required. The contamination within a controlled area is normally regularly monitored. Radiological protection instrumentation (RPI) plays a key role in monitoring and detecting any potential contamination spread, and combinations of hand held survey instruments and permanently installed area monitors such as Airborne particulate monitors and area gamma monitors

are often installed. Detection and measurement of surface contamination of personnel and plant is normally by Geiger counter, scintillation counter or proportional counter. Proportional counters and dual phosphor scintillation counters can discriminate between alpha and beta contamination, but the Geiger counter cannot. Scintillation detectors are generally preferred for hand held monitoring instruments, and are designed with a large detection window to make monitoring of large areas faster. Geiger detectors tend to have small windows, which are more suited to small areas of contamination.

Exit monitoring

The spread of contamination by personnel exiting controlled areas in which nuclear material is used or processed is monitored by specialised installed exit control instruments such as frisk probes, hand contamination monitors and whole body exit monitors. These are used to check that persons exiting controlled areas do not carry contamination on their body or clothes.

In the United Kingdom the HSE has issued a user guidance note on selecting the correct portable radiation measurement instrument for the application concerned. This covers all radiation instrument technologies, and is a useful comparative guide for selecting the correct technology for the contamination type.

The UK NPL publishes a guide on the alarm levels to be used with instruments for checking personnel exiting controlled areas in which contamination may be encountered. Surface contamination is usually expressed in units of radioactivity per unit of area for alpha or beta emitters. For SI, this is becquerels per square meter (or Bq/m). Other units such as pico Curies per 100 cm or disintegrations per minute per square centimeter (1 dpm/cm = 167 Bq/m) may be used.

Airborne contamination

The air can be contaminated with radioactive isotopes in particulate form, which poses a particular inhalation hazard. Respirators with suitable air filters, or completely self-contained suits with their own air supply can mitigate these dangers.

Airborne contamination is measured by specialist radiological instruments that continuously pump the sampled air through a filter. Airborne particles accumulate on the filter and can be measured in a number of ways:

1. The filter paper is periodically manually removed to an instrument such as a "scaler" which measures any accumulated radioactivity.
2. The filter paper is static and is measured in situ by a radiation detector.
3. The filter is a slowly moving strip and is measured by a radiation detector. These are commonly called "moving filter" devices and automatically advance the filter to present a clean area for accumulation, and thereby allow a plot of airborne concentration over time.

Commonly a semiconductor radiation detection sensor is used that can also provide spectrographic information on the contamination being collected.

A particular problem with airborne contamination monitors designed to detect alpha particles is that naturally occurring radon can be quite prevalent and may appear as contamination when low contamination levels are being sought. Modern instruments consequently have "radon compensation" to overcome this effect.

See the article on Airborne particulate radioactivity monitoring for more information.

Internal human contamination

Radioactive contamination can enter the body through ingestion, inhalation, absorption, or injection. This will result in a committed dose of radiation.

For this reason, it is important to use personal protective equipment when working with radioactive materials. Radioactive contamination may also be ingested as the result of eating contaminated plants and animals or drinking contaminated water or milk from exposed animals. Following a major contamination incident, all potential pathways of internal exposure should be considered.

Successfully used on Harold McCluskey, chelation therapy and other treatments exist for internal radionuclide contamination.

Decontamination

Cleaning up contamination results in radioactive waste unless the radioactive material can be returned to commercial use by reprocessing. In some cases of large areas of contamination, the contamination may be mitigated by burying and covering the contaminated substances with concrete, soil, or rock to prevent further spread of the contamination to the environment. If a person's body is contaminated by ingestion or by injury and standard cleaning cannot reduce the contamination further, then the person may be permanently contaminated.

Contamination control products have been used by the U.S. Department of Energy (DOE) and the commercial nuclear industry for decades to minimize contamination on radioactive equipment and surfaces and fix contamination in place. "Contamination control products" is a broad term that includes fixatives, strippable coatings, and decontamination gels. A *fixative* product functions as a permanent coating to stabilize residual loose/transferable radioactive contamination by fixing it in place; this aids in preventing the spread of contamination and reduces the possibility of the contamination becoming airborne, reducing workforce exposure and facilitating future deactivation and decommissioning (D&D) activities. *Strippable coating* products are loosely adhered paint-like films and are used for their decontamination abilities. They are applied to surfaces with

loose/transferable radioactive contamination and then, once dried, are peeled off, which removes the loose/transferable contamination along with the product. The residual radioactive contamination on the surface is significantly reduced once the strippable coating is removed. Modern strippable coatings show high decontamination efficiency and can rival traditional mechanical and chemical decontamination methods. *Decontamination gels* work in much the same way as other strippable coatings. The results obtained through the use of contamination control products is variable and depends on the type of substrate, the selected contamination control product, the contaminants, and the environmental conditions (e.g., temperature, humidity, etc.).

Some of the largest areas committed to be decontaminated are in the Fukushima Prefecture, Japan. The national government is under pressure to clean up radioactivity due to the Fukushima nuclear accident of March 2011 from as much land as possible so that some of the 110,000 displaced people can return. Stripping out the key radioisotope threatening health (caesium-137) from low level waste could also dramatically decrease the volume of waste requiring special disposal. A goal is to find techniques that might be able to strip out 80 to 95% of the caesium from contaminated soil and other materials, efficiently and without destroying the organic content in the soil. One being investigated is termed hydrothermal blasting. The caesium is broken away from soil particles and then precipitated with ferric ferricyanide (Prussian blue). It would be the only component of the waste requiring special burial sites. The aim is to get annual exposure from the contaminated environment down to one millisievert (mSv) above background. The most contaminated area where radiation doses are greater than 50 mSv/year must remain off limits, but some areas that are currently less than 5 mSv/year may be decontaminated allowing 22,000 residents to return.

To help with protection of people living in geographical areas which have been radioactively contaminated the International Commission on Radiological Protection has published a guide: "Publication 111 – Application of the Commission's Recommendations to the Protection of People Living in Long-term Contaminated Areas after a Nuclear Accident or a Radiation Emergency".

Contamination hazards

Low-level contamination

The hazards to people and the environment from radioactive contamination depend on the nature of the radioactive contaminant, the level of contamination, and the extent of the spread of contamination. Low levels of radioactive contamination pose little risk, but can still be detected by radiation instrumentation. If a survey or map is made of a contaminated area, random sampling locations may be labeled with their activity in becquerels or curies on contact. Low levels may be reported in counts per minute using a scintillation counter.

In the case of low-level contamination by isotopes with a short half-life, the best course of action may be to simply allow the material to naturally decay. Longer-lived isotopes should be cleaned up and properly disposed of, because even a very low level of radiation can be life-threatening when in long exposure to it.

Facilities and physical locations that are deemed to be contaminated may be cordoned off by a health physicist and labeled "Contaminated area." Persons coming near such an area would typically require anti-contamination clothing ("anti-Cs").

High-level contamination

High levels of contamination may pose major risks to people and the environment. People can be exposed to potentially lethal radiation levels, both externally and internally, from the spread of contamination following an accident (or a deliberate initiation) involving large quantities of radioactive material. The biological effects of external exposure to radioactive contamination are generally the same as those from an external radiation source not involving radioactive materials, such as x-ray machines, and are dependent on the absorbed dose.

When radioactive contamination is being measured or mapped *in situ*, any location that appears to be a point source of radiation is likely to be heavily contaminated. A highly contaminated location is colloquially referred to as a "hot spot." On a map of a contaminated place, hot spots may be labeled with their "on contact" dose rate in mSv/h. In a contaminated facility, hot spots may be marked with a sign, shielded with bags of lead shot, or cordoned off with warning tape containing the radioactive trefoil symbol.

The hazard from contamination is the emission of ionising radiation. The principal radiations which will be encountered are alpha, beta and gamma, but these have quite different characteristics. They have widely differing penetrating powers and radiation effect, and the accompanying diagram shows the penetration of these radiations in simple terms. For an understanding of the different ionising effects of these radiations and the weighting factors applied, see the article on absorbed dose.

Radiation monitoring involves the measurement of radiation dose or radionuclide contamination for reasons related to the assessment or control of exposure to radiation or radioactive substances, and the interpretation of the results. The methodological and technical details of the design and operation of environmental radiation monitoring programmes and systems for different radio nuclides, environmental media and types of facility are given in IAEA Safety Standards Series No. RS-G-1.8 and in IAEA Safety Reports Series No. 64.

Health effects of contamination

Biological effects

Radioactive contamination by definition emits ionizing radiation, which can irradiate the human body from an external or internal origin.

External irradiation

This is due to radiation from contamination located outside the human body. The source can be in the vicinity of the body or can be on the skin surface. The level of health risk is dependent on duration and the type and strength of irradiation. Penetrating radiation such as gamma rays, X-rays, neutrons or beta particles pose the greatest risk from an external source. Low penetrating radiation such as alpha particles have a low external risk due to the shielding effect of the top layers of skin.

Internal irradiation

Radioactive contamination can be ingested into the human body if it is airborne or is taken in as contamination of food or drink, and will irradiate the body internally. The art and science of assessing internally generated radiation dose is Internal dosimetry.

The biological effects of ingested radionuclides depend greatly on the activity, the biodistribution, and the removal rates of the radionuclide, which in turn depends on its chemical form, the particle size, and route of entry. Effects may also depend on the chemical toxicity of the deposited material, independent of its radioactivity. Some radionuclides may be generally distributed throughout the body and rapidly removed, as is the case with tritiated water.

Some organs concentrate certain elements and hence radionuclide variants of those elements. This action may lead to much lower removal rates. For instance, the thyroid gland takes up a large percentage of any iodine that enters the body. Large quantities of inhaled or ingested radioactive iodine may impair or destroy the thyroid, while other tissues are affected to a lesser extent. Radioactive iodine-131 is a common fission product; it was a major component of the radioactivity released from the Chernobyl disaster, leading to nine fatal cases of pediatric thyroid cancer and hypothyroidism. On the other hand, radioactive iodine is used in the diagnosis and treatment of many diseases of the thyroid precisely because of the thyroid's selective uptake of iodine.

The radiation risk proposed by the International Commission on Radiological Protection (ICRP) predicts that an effective dose of one sievert (100 rem) carries a 5.5% chance of developing cancer. Such a risk is the sum of both internal and external radiation dose.

The ICRP states "Radionuclides incorporated in the human body irradiate the tissues over time periods determined by their physical half-life and their biological retention within the body. Thus they may give rise to doses to body tissues for many months or years after the intake. The need to regulate

exposures to radionuclides and the accumulation of radiation dose over extended periods of time has led to the definition of committed dose quantities". The ICRP further states "For internal exposure, committed effective doses are generally determined from an assessment of the intakes of radionuclides from bioassay measurements or other quantities (e.g., activity retained in the body or in daily excreta). The radiation dose is determined from the intake using recommended dose coefficients".

The ICRP defines two dose quantities for individual committed dose:

Committed equivalent dose, $H_T(t)$ is the time integral of the equivalent dose rate in a particular tissue or organ that will be received by an individual following intake of radioactive material into the body by a Reference Person, where t is the integration time in years. This refers specifically to the dose in a specific tissue or organ, in a similar way to external equivalent dose.

Committed effective dose, $E(t)$ is the sum of the products of the committed organ or tissue equivalent doses and the appropriate tissue weighting factors W_T , where t is the integration time in years following the intake. The commitment period is taken to be 50 years for adults, and to age 70 years for children. This refers specifically to the dose to the whole body, in a similar way to external effective dose.

Social and psychological effects

A 2015 report in *Lancet* explained that serious impacts of nuclear accidents were often not directly attributable to radiation exposure, but rather social and psychological effects. The consequences of low-level radiation are often more psychological than radiological. Because damage from very-low-level radiation cannot be detected, people exposed to it are left in anguished uncertainty about what will happen to them. Many believe they have been fundamentally contaminated for life and may refuse to have children for fear of birth defects. They may be shunned by others in their community who fear a sort of mysterious contagion.

Forced evacuation from a radiological or nuclear accident may lead to social isolation, anxiety, depression, psychosomatic medical problems, reckless behavior, even suicide. Such was the outcome of the 1986 Chernobyl nuclear disaster in Ukraine. A comprehensive 2005 study concluded that "the mental health impact of Chernobyl is the largest public health problem unleashed by the accident to date". Frank N. von Hippel, a U.S. scientist, commented on 2011 Fukushima nuclear disaster, saying that "fear of ionizing radiation could have long-term psychological effects on a large portion of the population in the contaminated areas". Evacuation and long-term displacement of affected populations create problems for many people, especially the elderly and hospital patients (Radioactive Contamination).

CHOLOFLUROCARBONS (CFCs)

Chlorofluorocarbons (CFCs) are fully halogenated paraffin hydrocarbons that contain only carbon (C), chlorine (Cl), and fluorine (F), produced as volatile derivative of methane, ethane, and propane. They are also commonly known by the DuPont brand name Freon. The most common representative is dichlorodifluoromethane (R-12 or Freon-12). Many CFCs have been widely used as refrigerants, propellants (in aerosol applications), and solvents.

CFCs and HCFCs are used in a variety of applications because of their low toxicity, reactivity and flammability. Every permutation of fluorine, chlorine and hydrogen based on methane and ethane has been examined and most have been commercialized. Furthermore, many examples are known for higher numbers of carbon as well as related compounds containing bromine. Uses include refrigerants, blowing agents, propellants in medicinal applications and degreasing solvents.

Billions of kilograms of chlorodifluoromethane are produced annually as precursor to tetrafluoroethylene, the monomer that is converted into Teflon.

Impact as greenhouse gases

As previously discussed, CFCs were phased out via the Montreal Protocol due to their part in ozone depletion. However, the atmospheric impacts of CFCs are not limited to their role as ozone depleting chemicals. Infrared absorption bands prevent heat at that wavelength from escaping earth's atmosphere. CFCs have their strongest absorption bands from C-F and C-Cl bonds in the spectral region of 7.8–15.3 μm – referred to as an “atmospheric window” due to the relative transparency of the atmosphere within this region.

The strength of CFC absorption bands and the unique susceptibility of the atmosphere at wavelengths where CFCs (indeed all covalent fluorine compounds) absorb creates a “super” greenhouse effect from CFCs and other unreactive fluorine-containing gases such as perfluorocarbons, HFCs, HCFCs, bromofluorocarbons, SF_6 , and NF_3 . This “atmospheric window” absorption is intensified by the low concentration of each individual CFC. Because CO_2 is close to saturation with high concentrations and few infrared absorption bands, the radiation budget and hence the greenhouse effect has low sensitivity to changes in CO_2 concentration: the increase in temperature is roughly logarithmic. Conversely, the low concentration of CFCs allow their effects to increase linearly with mass, so that chlorofluorocarbons are greenhouse gases with a much higher potential to enhance the greenhouse effect than CO_2 . Groups are actively disposing of legacy CFCs to reduce their impact on the atmosphere

Regulation

Since the late 1970s, the use of CFCs has been heavily regulated because of their destructive effects on the ozone layer. After the development of his electron capture detector, James Lovelock was the

first to detect the widespread presence of CFCs in the air, finding a mole fraction of 60 ppt of CFC-11 over Ireland. In a self-funded research expedition ending in 1973, Lovelock went on to measure CFC-11 in both the Arctic and Antarctic, finding the presence of the gas in each of 50 air samples collected, and concluding that CFCs are not hazardous to the environment. The experiment did however provide the first useful data on the presence of CFCs in the atmosphere. The damage caused by CFCs was discovered by Sherry Rowland and Mario Molina who, after hearing a lecture on the subject of Lovelock's work, embarked on research resulting in the first publication suggesting the connection in 1974. It turns out that one of CFCs' most attractive features—their low reactivity—is key to their most destructive effects. CFCs' lack of reactivity gives them a lifespan that can exceed 100 years, giving them time to diffuse into the upper stratosphere. Once in the stratosphere, the sun's ultraviolet radiation is strong enough to cause the homolytic cleavage of the C-Cl bond. In 1978, under the Toxic Substances Control Act, the EPA banned commercial manufacturing and use of CFCs and aerosol propellants. This was later superseded by broader regulation by the EPA under the Clean Air Act to address stratospheric ozone depletion.

By 1987, in response to a dramatic seasonal depletion of the ozone layer over Antarctica, diplomats in Montreal forged a treaty, the Montreal Protocol, which called for drastic reductions in the production of CFCs. On 2 March 1989, 12 European Community nations agreed to ban the production of all CFCs by the end of the century. In 1990, diplomats met in London and voted to significantly strengthen the Montreal Protocol by calling for a complete elimination of CFCs by the year 2000. By the year 2010, CFCs should have been completely eliminated from developing countries as well.

Because the only CFCs available to countries adhering to the treaty is from recycling, their prices have increased considerably. A worldwide end to production should also terminate the smuggling of this material. However, there are current CFC smuggling issues, as recognized by the United Nations Environmental Programme (UNEP) in a 2006 report titled "Illegal Trade in Ozone Depleting Substances". UNEP estimates that between 16,000–38,000 tonnes of CFCs passed through the black market in the mid-1990s. The report estimated between 7,000 and 14,000 tonnes of CFCs are smuggled annually into developing countries. Asian countries are those with the most smuggling; as of 2007, China, India and South Korea were found to account for around 70% of global CFC production, South Korea later to ban CFC production in 2010. Possible reasons for continued CFC smuggling were also examined: the report noted that many banned CFC producing products have long lifespans and continue to operate. The cost of replacing the equipment of these items is sometimes cheaper than outfitting them with a more ozone-friendly appliance. Additionally, CFC smuggling is not considered a significant issue, so the perceived penalties for smuggling are low. In 2018 public attention was drawn to the issue, that at an unknown place in east Asia an estimated amount of 13,000 metric tons annually of CFCs have been produced since about 2012 in violation of the protocol. While the eventual phaseout of CFCs is likely, efforts are being taken to stem these current non-compliance problems.

By the time of the Montreal Protocol, it was realised that deliberate and accidental discharges during system tests and maintenance accounted for substantially larger volumes than emergency discharges, and consequently halons were brought into the treaty, albeit with many exceptions.

Regulatory gap

While the production and consumption of CFCs are regulated under the Montreal Protocol, emissions from existing banks of CFCs are not regulated under the agreement. In 2002, there were an estimated 5,791 kilotons of CFCs in existing products such as refrigerators, air conditioners, aerosol cans and others. Approximately one-third of these CFCs are projected to be emitted over the next decade if action is not taken, posing a threat to both the ozone layer and the climate. A proportion of these CFCs can be safely captured and destroyed.

Development of alternatives for CFCs

Work on alternatives for chlorofluorocarbons in refrigerants began in the late 1970s after the first warnings of damage to stratospheric ozone were published.

The hydrochloro fluorocarbons (HCFCs) are less stable in the lower atmosphere, enabling them to break down before reaching the ozone layer. Nevertheless, a significant fraction of the HCFCs do break down in the stratosphere and they have contributed to more chlorine buildup there than originally predicted. Later alternatives lacking the chlorine, the hydro fluorocarbons (HFCs) have an even shorter lifetimes in the lower atmosphere. One of these compounds, HFC-134a, is now used in place of CFC-12 in automobile air conditioners. Hydrocarbon refrigerants (a propane/isobutane blend) are also used extensively in mobile air conditioning systems in Australia, the USA and many other countries, as they have excellent thermodynamic properties and perform particularly well in high ambient temperatures.

Among the natural refrigerants (along with ammonia and carbon dioxide), hydrocarbons have negligible environmental impacts and are also used worldwide in domestic and commercial refrigeration applications, and are becoming available in new split system air conditioners. Various other solvents and methods have replaced the use of CFCs in laboratory analytics.

In Metered-dose inhalers (MDI), a non-ozone effecting substitute was developed as a propellant, known as "**hydrofluoroalkane**" (Chlorofluorocarbon).

PLASTIC POLLUTION

Plastic pollution is the accumulation of plastic objects (e.g.: plastic bottles and much more) in the Earth's environment that adversely affects wildlife, wildlife habitat, and humans. Plastics that act as pollutants are categorized into micro-, meso-, or macro debris, based on size. Plastics are inexpensive and durable, and as a result levels of plastic production by humans are high. However, the chemical structure of most plastics renders them resistant to many natural processes of

degradation and as a result they are slow to degrade. Together, these two factors have led to a high prominence of plastic pollution in the environment.

Plastic pollution can afflict land, waterways and oceans. It is estimated that 1.1 to 8.8 million metric tons (MT) of plastic waste enters the ocean from coastal communities each year. Living organisms, particularly marine animals, can be harmed either by mechanical effects, such as entanglement in plastic objects or problems related to ingestion of plastic waste, or through exposure to chemicals within plastics that interfere with their physiology. Humans are also affected by plastic pollution, such as through disruption of various hormonal mechanisms.

As of 2018, about 380 million tons of plastic is produced worldwide each year. From the 1950s up to 2018, an estimated 6.3 billion tons of plastic has been produced worldwide, of which an estimated 9% has been recycled and another 12% has been incinerated. In the UK alone, more than 5 million tonnes of plastic are consumed each year, of which only an estimated one-quarter is recycled, with the remainder going to landfills. This large amount of plastic waste inevitably enters the environment, with studies suggesting that the bodies of 90% of seabirds contain plastic debris. In some areas there have been significant efforts to reduce the prominence of plastic pollution, through reducing plastic consumption and promoting plastic recycling.

Some researchers suggest that by 2050 there could be more plastic than fish in the oceans by weight.

Types of plastic debris

There are three major forms of plastic that contribute to plastic pollution: micro plastics as well as mega- and macro-plastics. Mega- and micro plastics have accumulated in highest densities in the Northern Hemisphere, concentrated around urban centers and water fronts. Plastic can be found off the coast of some islands because of currents carrying the debris. Both mega- and macro-plastics are found in packaging, footwear, and other domestic items that have been washed off of ships or discarded in landfills. Fishing-related items are more likely to be found around remote islands. These may also be referred to as micro-, meso-, and macro debris.

Plastic debris is categorized as either primary or secondary. Primary plastics are in their original form when collected. Examples of these would be bottle caps, cigarette butts, and micro beads. Secondary plastics, on the other hand, account for smaller plastics that have resulted from the degradation of primary plastics.

Microdebris

Microdebris are plastic pieces between 2 mm and 5 mm in size. Plastic debris that starts off as meso- or macrodebris can become microdebris through degradation and collisions that break it down into smaller pieces. Microdebris is more commonly referred to as nurdles. Nurdles are recycled to make new plastic items, but they easily end up released into the environment during production because of

their small size. They often end up in ocean waters through rivers and streams. Microdebris that come from cleaning and cosmetic products are also referred to as scrubbers. Because microdebris and scrubbers are so small in size, filter-feeding organisms often consume them.

Primary microplastics, a type of microdebris, known as Nurdles enter the ocean by means of spills during transportation or from land based sources. These micro-plastics can accumulate in the oceans and allow for the accumulation of Persistent Bio-accumulating Toxins such as DDT and PCB's which are hydrophobic in nature and can cause adverse health effects.

A 2004 study by Richard Thompson from the University of Plymouth, UK, found a great amount of microdebris on the beaches and waters in Europe, the Americas, Australia, Africa, and Antarctica. Thompson and his associates found that plastic pellets from both domestic and industrial sources were being broken down into much smaller plastic pieces, some having a diameter smaller than human hair. If not ingested, this microdebris floats instead of being absorbed into the marine environment. Thompson predicts there may be 300,000 plastic items/km of sea surface and 100,000 plastic particles/km of seabed. International pellet watch collected samples of polythene pellets from 30 beaches from 17 countries which were then analysed for organic micro-pollutants. It was found that pellets found on beaches in America, Vietnam and southern Africa contained compounds from pesticides suggesting a high use of pesticides in the areas.

Macrodebris

Plastic debris is categorized as macrodebris when it is larger than 20 mm. These include items such as plastic grocery bags. Macrodebris are often found in ocean waters, and can have a serious impact on the native organisms. Fishing nets have been prime pollutants. Even after they have been abandoned, they continue to trap marine organisms and other plastic debris. Eventually, these abandoned nets become too difficult to remove from the water because they become too heavy, having grown in weight up to 6 tons.

Decomposition of plastics

Plastics themselves contribute to approximately 10% of discarded waste. Many kinds of plastics exist depending on their precursors and the method for their polymerization. Depending on their chemical composition, plastics and resins have varying properties related to contaminant absorption and adsorption. Polymer degradation takes much longer as a result of saline environments and the cooling effect of the sea. These factors contribute to the persistence of plastic debris in certain environments. Recent studies have shown that plastics in the ocean decompose faster than was once thought, due to exposure to sun, rain, and other environmental conditions, resulting in the release of toxic chemicals such as bisphenol A. However, due to the increased volume of plastics in the ocean, decomposition has slowed down. The Marine Conservancy has predicted the decomposition rates of several plastic products. It is estimated that a foam plastic cup will take 50 years, a plastic beverage holder will take 400 years, a disposable nappy will take 450 years, and fishing line will take 600 years to degrade.

Persistent organic pollutants

It was estimated that global production of plastics is approximately 250 mt/yr. Their abundance has been found to transport persistent organic pollutants, also known as POPs. These pollutants have been linked to an increased distribution of algae associated with red tides.

Effects on the environment

The distribution of plastic debris is highly variable as a result of certain factors such as wind and ocean currents, coastline geography, urban areas, and trade routes. Human population in certain areas also plays a large role in this. Plastics are more likely to be found in enclosed regions such as the Caribbean. It serves as a means of distribution of organisms to remote coasts that are not their native environments. This could potentially increase the variability and dispersal of organisms in specific areas that are less biologically diverse. Plastics can also be used as vectors for chemical contaminants such as persistent organic pollutants and heavy metals.

Plastic pollution as one of the causes of Climate change

In 2019 a new report "Plastic and Climate" was published. According to the report plastic will contribute Greenhouse gases in the equivalent of 850 million tons of Carbon dioxide (CO₂) to the atmosphere in 2019. In current trend, annual emissions will grow to 1.34 billion tons by 2030. By 2050 plastic could emit 56 billion tons of Greenhouse gas emissions, as much as 14 percent of the earth's remaining carbon budget.

Effects of plastic on land

Chlorinated plastic can release harmful chemicals into the surrounding soil, which can then seep into groundwater or other surrounding water sources and also the ecosystem of the world. This can cause serious harm to the species that drink the water.

Landfill areas contain many different types of plastics. In these landfills, there are many microorganisms which speed up the biodegradation of plastics. The microorganisms include bacteria such as *Pseudomonas*, nylon-eating bacteria, and Flavobacteria. These bacteria break down nylon through the activity of the nylonase enzyme. Breakdown of biodegradable plastics releases methane, a very powerful greenhouse gas that contributes significantly to global warming.

Effects of plastic on oceans

In 2012, it was estimated that there was approximately 165 million tons of plastic pollution in the world's oceans. One type of plastic that is of concern in terms of ocean plastic pollution is nurdles. Nurdles are manufactured plastic pellets (a type of microplastic) used in the creation of plastic products and are often shipped via cargo ship. Many billions of nurdles are spilled into oceans each year, and it has been estimated that globally, around 10% of beach litter consists of nurdles. Plastics in

oceans typically degrade within a year, but not entirely. In the process, toxic chemicals such as bisphenol A and polystyrene can leach into waters from some plastics. Polystyrene pieces and nurdles are the most common types of plastic pollution in oceans, and combined with plastic bags and food containers make up the majority of oceanic debris.

One study estimated that there are more than 5 trillion plastic pieces (defined into the four classes of small microplastics, large microplastics, meso- and macroplastics) afloat at sea.

The litter that is being delivered into the oceans is toxic to marine life, and humans. The toxins that are components of plastic include diethylhexyl phthalate, which is a toxic carcinogen, as well as lead, cadmium, and mercury.

Plankton, fish, and ultimately the human race, through the food chain, ingest these highly toxic carcinogens and chemicals. Consuming the fish that contain these toxins can cause an increase in cancer, immune disorders, and birth defects.

The majority of the litter near and in the ocean is made up of plastics and is a persistent pervasive source of marine pollution. According to Dr. Marcus Eriksen of The 5 Gyres Institute, there are 5.25 trillion particles of plastic pollution that weigh as much as 270,000 tons (2016). This plastic is taken by the ocean currents and accumulates in large vortexes known as ocean gyres. The majority of the gyres become pollution dumps filled with plastic.

Sources of ocean-based plastic pollution

Almost 20% of plastic debris that pollutes ocean water, which translates to 5.6 million tons, comes from ocean-based sources. MARPOL, an international treaty, "imposes a complete ban on the at-sea disposal of plastics". Merchant ships expel cargo, sewage, used medical equipment, and other types of waste that contain plastic into the ocean. In the United States, the Marine Plastic Pollution Research and Control Act of 1987 prohibits discharge of plastics in the sea, including from naval vessels. Naval and research vessels eject waste and military equipment that are deemed unnecessary. Pleasure crafts release fishing gear and other types of waste, either accidentally or through negligent handling. The largest ocean-based source of plastic pollution is discarded fishing gear (including traps and nets), estimated to be up to 90% of plastic debris in some areas.

Continental plastic litter enters the ocean largely through storm-water runoff, flowing into watercourses or directly discharged into coastal waters. Plastic in the ocean has been shown to follow ocean currents which eventually form into what is known as Great Garbage Patches. Knowledge of the routes that plastic follows in ocean currents comes from accidental container drops from ship carriers. For example, in May 1990 The Hansa Carrier, sailing from Korea to the United States, broke apart due to a storm, ultimately resulting in thousands of dumped shoes; these eventually started showing up on the U.S western coast, and Hawaii.

Land-based sources of ocean plastic pollution

Estimates for the contribution of land-based plastic vary widely. While one study estimated that a little over 80% of plastic debris in ocean water comes from land-based sources, responsible for 0.8 million tonnes (790,000 long tons; 880,000 short tons) every year. In 2015, Jambeck et al. calculated that 275 million tonnes (271,000,000 long tons; 303,000,000 short tons) of plastic waste was generated in 192 coastal countries in 2010, with 4.8 to 12.7 million tonnes (12,500,000 long tons; 14,000,000 short tons) entering the ocean - a percentage of only up to 5%.

In a study published by *Science*, Jambeck *et al* (2015) estimated that the 10 largest emitters of oceanic plastic pollution worldwide are, from the most to the least, China, Indonesia, Philippines, Vietnam, Sri Lanka, Thailand, Egypt, Malaysia, Nigeria, and Bangladesh.

In a study published by *Environmental Science & Technology*, Schmidt *et al* (2017) calculated that the Yangtze, Indus, Yellow River, Hai River, Nile, Ganges, Pearl River, Amur, Niger, and the Mekong "transport 88–95% of the global [plastics] load into the sea."

A source that has caused concern is landfills. Most waste in the form of plastic in landfills are single-use items such as packaging. Discarding plastics this way leads to accumulation. Although disposing of plastic waste in landfills has less of a gas emission risk than disposal through incineration, the former has space limitations. Another concern is that the liners acting as protective layers between the landfill and environment can break, thus leaking toxins and contaminating the nearby soil and water. Landfills located near oceans often contribute to ocean debris because content is easily swept up and transported to the sea by wind or small waterways like rivers and streams. Marine debris can also result from sewage water that has not been efficiently treated, which is eventually transported to the ocean through rivers. Plastic items that have been improperly discarded can also be carried to oceans through storm waters.

Biodegradable and degradable plastics

The use of biodegradable plastics has many advantages and disadvantages. Biodegradables are biopolymers that degrade in industrial composters. Biodegradables do not degrade as efficiently in domestic composters, and during this slower process, methane gas may be emitted.

There are also other types of degradable materials that are not considered to be biopolymers, because they are oil-based, similar to other conventional plastics. These plastics are made to be more degradable through the use of different additives, which help them degrade when exposed to UV rays or other physical stressors. yet, biodegradation-promoting additives for polymers have been shown not to significantly increase biodegradation.

Although biodegradable and degradable plastics have helped reduce plastic pollution, there are some drawbacks. One issue concerning both types of plastics is that they do not break down very efficiently in natural environments. There, degradable plastics that are oil-based may break down into smaller fractions, at which point they do not degrade further.

Incineration

Up to 60% of used plastic medical equipment is incinerated rather than deposited in a landfill as a precautionary measure to lessen the transmission of disease. This has allowed for a large decrease in the amount of plastic waste that stems from medical equipment. If plastic waste is not incinerated and disposed of properly, a harmful amount of toxins can be released and dispersed as a gas through air or as ash through air and waterways. Many studies have been done concerning the gaseous emissions that result from the incineration process.

Policy

Agencies such as the US Environmental Protection Agency and US Food and Drug Administration often do not assess the safety of new chemicals until after a negative side effect is shown. Once they suspect a chemical may be toxic, it is studied to determine the human reference dose, which is determined to be the lowest observable adverse effect level. During these studies, a high dose is tested to see if it causes any adverse health effects, and if it does not, lower doses are considered to be safe as well. This does not take into account the fact that with some chemicals found in plastics, such as BPA; lower doses can have a discernible effect. Even with this often complex evaluation process, policies have been put into place in order to help alleviate plastic pollution and its effects. Government regulations have been implemented that ban some chemicals from being used in specific plastic products.

In Canada, the United States, and the European Union, BPA has been banned from being incorporated in the production of baby bottles and children's cups, due to health concerns and the higher vulnerability of younger children to the effects of BPA. Taxes have been established in order to discourage specific ways of managing plastic waste. The landfill tax, for example, creates an incentive to choose to recycle plastics rather than contain them in landfills, by making the latter more expensive. There has also been a standardization of the types of plastics that can be considered compostable. The European Norm EN 13432, which was set by the European Committee for Standardization (CEN), lists the standards that plastics must meet, in terms of compostability and biodegradability, in order to officially be labeled as compostable.

Collection

The two common forms of waste collection include curbside collection and the use of drop-off recycling centers. About 87 percent of the population in the United States (273 million people) have access to curbside and drop-off recycling centers. In curbside collection, which is available to about 63 percent of the United States population (193 million people), people place designated plastics in a special bin to be picked up by a public or private hauling company. Most curbside programs collect more than one type of plastic resin; usually both PETE and HDPE. At drop-off recycling centers, which are available to 68 percent of the United States population (213 million people), people take their recyclables to a centrally located facility. Once collected, the plastics are delivered to a materials recovery facility (MRF) or handler for sorting into single-resin streams to increase product value. The sorted plastics are then baled to reduce shipping costs to reclaimers.

There are varying rates of recycling per type of plastic, and in 2011, the overall plastic recycling rate was approximately 8% in the United States. Approximately 2.7 million tons of plastics were recycled in the U.S. in 2011. Some plastics are recycled more than others; in 2011 "29 percent of HDPE bottles and 29 percent of PET bottles and jars were recycled."

In May 2019, a new model to collect packaging from consumers and reuse it will begin. It is called "Loop". Consumers will drop the package in special shipping totes and then a pick up will take it. "Partners include Procter & Gamble, Nestlé, PepsiCo, Unilever, Mars Petcare, The Clorox Company, The Body Shop, Coca-Cola, Mondelēz, Danone and other firms.

Non-usage and reduction in usage

The Ministry of Drinking Water and Sanitation, Government of India, has requested various governmental departments to avoid the use of plastic bottles to provide drinking water during governmental meetings, etc., and to instead make arrangements for providing drinking water that do not generate plastic waste. The state of Sikkim has restricted the usage of plastic water bottles (in government functions and meetings) and styrofoam products. The state of Bihar has banned the usage of plastic water bottles in governmental meetings.

The 2015 National Games of India, organised in Thiruvananthapuram, was associated with green protocols. This was initiated by Suchitwa Mission that aimed for "zero-waste" venues. To make the event "disposable-free", there was ban on the usage of disposable water bottles. The event witnessed the usage of reusable tableware and stainless steel tumblers. Athletes were provided with refillable steel flasks. It is estimated that these green practices stopped the generation of 120 metric tonnes of disposable waste.

The state of Maharashtra, India effected the Maharashtra Plastic and Thermocol Products ban 23 June 2018, subjecting plastic users to fines and potential imprisonment for repeat offenders.

In July 2018, Albania became the first country in Europe to ban lightweight plastic bags. Albania's environment minister Blendi Klosi said that businesses importing, producing or trading plastic bags less than 35 microns in thickness risk facing fines between 1 million to 1.5 million lek (€7,900 to €11,800).

In January 2019, Nestlé announced that it will phase-out the use of plastic straws starting in February 2019 and will end the use of plastic packaging that is not recyclable or reusable by 2025.

In January 2019, the Iceland supermarket chain, which specializes in frozen foods, pledged to "eliminate or drastically reduce all plastic packaging for its store-brand products by 2023."

In Bali, a pair of two sisters, Melati and Isabel Wijsen, have gone through efforts to ban plastic bags in 2019. Their organization Bye Bye Plastic Bags has spread to 28 locations around the world.

In 2019 The New York (state) banned single use plastic bags and introduced a 5 cent fee for using single use paper bags. The ban will enter into force in 2020. This will not only reduce plastic bag usage in New York state (23,000,000,000 every year until now), but also eliminate 12 million barrels of oil used to make plastic bags used by the state each year.

Action for creating awareness

On 11 April 2013 in order to create awareness, artist Maria Cristina Finucci founded The Garbage Patch State at UNESCO –Paris in front of Director General Irina Bokova. First of a series of events under the patronage of UNESCO and of Italian Ministry of the Environment. International organisations have also been raising awareness of plastic pollution.

Every year, June 5 is observed as World Environment Day to raise awareness and increase government action on the pressing issue. In 2018, India was host to the 43rd World Environment Day and the theme was 'Beat Plastic Pollution' with focus on single-use or disposable plastic. The Ministry of Environment, Forest and Climate Change of India invited people to take care of their social responsibility and urged them to take up green good deeds in everyday life. Several states presented plans to ban plastic or drastically reduce the use (Plastic pollution).

UNIT-16: SOURCES, IMPACTS AND MITIGATION MEASURES OF LEAD, ARSENIC AND FLUORIDE CONTAMINATIONS

Lead poisoning is a type of metal poisoning caused by lead in the body. The brain is the most sensitive. Symptoms may include abdominal pain, constipation, headaches, irritability, memory problems, inability to have children, and tingling in the hands and feet. It causes almost 10%

of intellectual disability of otherwise unknown cause and can result in behavioral problems. Some of the effects are permanent. In severe cases anemia, seizures, coma, or death may occur.

Exposure to lead can occur by contaminated air, water, dust, food, or consumer products. Children are at greater risk as they are more likely to put objects in their mouth such as those that contain lead paint and absorb a greater proportion of the lead that they eat. Exposure at work is a common cause of lead poisoning in adults with certain occupations at particular risk. Diagnosis is typically by measurement of the blood lead level. The Centers for Disease Control (US) has set the upper limit for blood lead for adults at 10 µg/dl (10 µg/100 g) and for children at 5 µg/dl. Elevated lead may also be detected by changes in red blood cells or dense lines in the bones of children as seen on X-ray.

Lead poisoning is preventable. This includes individual efforts such as removing lead-containing items from the home, workplace efforts such as improved ventilation and monitoring, and nationwide policies such as laws that ban lead in products such as paint and gasoline, reduce allowable levels in water or soil, and provide for cleanup of contaminated soil. The major treatments are removal of the source of lead and the use of medications that bind lead so it can be eliminated from the body, known as chelation therapy. Chelation therapy in children is recommended when blood levels are greater than 40–45 µg/dl. Medications used include dimercaprol, edetate calcium disodium, and succimer.

In 2016, lead is believed to have resulted in 540,000 deaths worldwide. It occurs most commonly in the developing world. Those who are poor are at greater risk. Lead is believed to result in 0.6% of the world's disease burden. People have been mining and using lead for thousands of years. Descriptions of lead poisoning date to at least 2000 BC, while efforts to limit lead's use date back to at least the 16th century. Concerns for low levels of exposure begin in the 1970s with there being no safe threshold for lead exposure.

Classification

Classically, "lead poisoning" or "lead intoxication" has been defined as exposure to high levels of lead typically associated with severe health effects. Poisoning is a pattern of symptoms that occur with toxic effects from mid to high levels of exposure; toxicity is a wider spectrum of effects, including subclinical ones (those that do not cause symptoms). However, professionals often use "lead poisoning" and "lead toxicity" interchangeably, and official sources do not always restrict the use of "lead poisoning" to refer only to symptomatic effects of lead.

The amount of lead in the blood and tissues, as well as the time course of exposure, determine toxicity. Lead poisoning may be acute (from intense exposure of short duration) or chronic (from repeat low-level exposure over a prolonged period), but the latter is much more common. Diagnosis and treatment of lead exposure are based on blood lead level (the amount of lead in the blood),

measured in micrograms of lead per deciliter of blood ($\mu\text{g/dL}$). Urine lead levels may be used as well, though less commonly. In cases of chronic exposure lead often sequesters in the highest concentrations first in the bones, then in the kidneys. If a provider is performing a provocative excretion test, or "chelation challenge", a measurement obtained from urine rather than blood is likely to provide a more accurate representation of total lead burden to a skilled interpreter.

The US Centers for Disease Control and Prevention and the World Health Organization state that a blood lead level of $10 \mu\text{g/dL}$ or above is a cause for concern; however, lead may impair development and have harmful health effects even at lower levels, and there is no known safe exposure level. Authorities such as the American Academy of Pediatrics define lead poisoning as blood lead levels higher than $10 \mu\text{g/dL}$.

Lead forms a variety of compounds and exists in the environment in various forms. Features of poisoning differ depending on whether the agent is an organic compound (one that contains carbon), or an inorganic one. Organic lead poisoning is now very rare, because countries across the world have phased out the use of organic lead compounds as gasoline additives, but such compounds are still used in industrial settings. Organic lead compounds, which cross the skin and respiratory tract easily, affect the central nervous system predominantly.

Signs and symptoms

Lead poisoning can cause a variety of symptoms and signs which vary depending on the individual and the duration of lead exposure. Symptoms are nonspecific and may be subtle, and someone with elevated lead levels may have no symptoms. Symptoms usually develop over weeks to months as lead builds up in the body during a chronic exposure, but acute symptoms from brief, intense exposures also occur. Symptoms from exposure to organic lead, which is probably more toxic than inorganic lead due to its lipid solubility, occur rapidly. Poisoning by organic lead compounds has symptoms predominantly in the central nervous system, such as insomnia, delirium, cognitive deficits, tremor, hallucinations, and convulsions.

Symptoms may be different in adults and children; the main symptoms in adults are headache, abdominal pain, memory loss, kidney failure, male reproductive problems, and weakness, pain, or tingling in the extremities.

Early symptoms of lead poisoning in adults are commonly nonspecific and include depression, loss of appetite, intermittent abdominal pain, nausea, diarrhoea, constipation, and muscle pain. Other early signs in adults include malaise, fatigue, decreased libido, and problems with sleep. An unusual taste in the mouth and personality changes are also early signs.

In adults, symptoms can occur at levels above 40 µg/dL, but are more likely to occur only above 50–60 µg/dL. Symptoms begin to appear in children generally at around 60 µg/dL. However, the lead levels at which symptoms appear vary widely depending on unknown characteristics of each individual. At blood lead levels between 25 and 60 µg/dL, neuropsychiatric effects such as delayed reaction times, irritability, and difficulty concentrating, as well as slowed motor nerve conduction and headache can occur. Anemia may appear at blood lead levels higher than 50 µg/dL. In adults, abdominal colic, involving paroxysms of pain, may appear at blood lead levels greater than 80 µg/dL. Signs that occur in adults at blood lead levels exceeding 100 µg/dL include wrist drop and foot drop, and signs of encephalopathy (a condition characterized by brain swelling), such as those that accompany increased pressure within the skull, delirium, coma, seizures, and headache. In children, signs of encephalopathy such as bizarre behavior, discoordination, and apathy occur at lead levels exceeding 70 µg/dL. For both adults and children, it is rare to be asymptomatic if blood lead levels exceed 100 µg/dL.

Acute poisoning

In acute poisoning, typical neurological signs are pain, muscle weakness, numbness and tingling, and, rarely, symptoms associated with inflammation of the brain. Abdominal pain, nausea, vomiting, diarrhea, and constipation are other acute symptoms. Lead's effects on the mouth include astringency and a metallic taste. Gastrointestinal problems, such as constipation, diarrhea, poor appetite, or weight loss, are common in acute poisoning. Absorption of large amounts of lead over a short time can cause shock (insufficient fluid in the circulatory system) due to loss of water from the gastrointestinal tract. Hemolysis (the rupture of red blood cells) due to acute poisoning can cause anemia and hemoglobin in the urine. Damage to kidneys can cause changes in urination such as decreased urine output. People who survive acute poisoning often go on to display symptoms of chronic poisoning.

Chronic poisoning

Chronic poisoning usually presents with symptoms affecting multiple systems, but is associated with three main types of symptoms: gastrointestinal, neuromuscular, and neurological. Central nervous system and neuromuscular symptoms usually result from intense exposure, while gastrointestinal symptoms usually result from exposure over longer periods. Signs of chronic exposure include loss of short-term memory or concentration, depression, nausea, abdominal pain, loss of coordination, and numbness and tingling in the extremities. Fatigue, problems with sleep, headaches, stupor, slurred speech, and anemia are also found in chronic lead poisoning. A "lead hue" of the skin with pallor and/or lividity is another feature. A blue line along the gum with bluish black edging to the teeth, known as a Burton line, is another indication of chronic lead poisoning. Children with chronic

poisoning may refuse to play or may have hyperkinetic or aggressive behavior disorders. Visual disturbance may present with gradually progressing blurred vision as a result of central scotoma, caused by toxic optic neuritis.

Effects on children

A woman who has elevated blood lead levels during pregnancy is at greater risk of a premature birth or with a low birth weight. Children are more at risk for lead poisoning because their smaller bodies are in a continuous state of growth and development. Lead is absorbed at a faster rate compared to adults, which causes more physical harm than to older people. Furthermore, children, especially as they are learning to crawl and walk, are constantly on the floor and therefore more prone to ingesting and inhaling dust that is contaminated with lead.

The classic signs and symptoms in children are loss of appetite, abdominal pain, vomiting, weight loss, constipation, anemia, kidney failure, irritability, lethargy, learning disabilities, and behavioral problems. Slow development of normal childhood behaviors, such as talking and use of words, and permanent intellectual disability are both commonly seen. Although less common, it is possible for fingernails to develop leukonychia striata if exposed to abnormally high lead concentrations.

By organ system

Lead affects every one of the body's organ systems, especially the nervous system, but also the bones and teeth, the kidneys, and the cardiovascular, immune, and reproductive systems. Hearing loss and tooth decay have been linked to lead exposure, as have cataracts. Intrauterine and neonatal lead exposure promote tooth decay. Aside from the developmental effects unique to young children, the health effects experienced by adults are similar to those in children, although the thresholds are generally higher.

Kidneys

Kidney damage occurs with exposure to high levels of lead, and evidence suggests that lower levels can damage kidneys as well. The toxic effect of lead causes nephropathy and may cause Fanconi syndrome, in which the proximal tubular function of the kidney is impaired. Long-term exposure at levels lower than those that cause lead nephropathy have also been reported as nephrotoxic in patients from developed countries that had chronic kidney disease or were at risk because of hypertension or diabetes mellitus. Lead poisoning inhibits excretion of the waste product urate and causes a predisposition for gout, in which urate builds up. This condition is known as *saturnine gout*.

Cardiovascular system

Evidence suggests lead exposure is associated with high blood pressure, and studies have also found connections between lead exposure and coronary heart disease, heart rate variability, and death from stroke, but this evidence is more limited. People who have been exposed to higher concentrations of lead may be at a higher risk for cardiac autonomic dysfunction on days when ozone and fine particles are higher.

Reproductive system

Lead affects both the male and female reproductive systems. In men, when blood lead levels exceed 40 µg/dL, sperm count is reduced and changes occur in volume of sperm, their motility, and their morphology. A pregnant woman's elevated blood lead level can lead to miscarriage, prematurity, low birth weight, and problems with development during childhood. Lead is able to pass through the placenta and into breast milk, and blood lead levels in mothers and infants are usually similar. A fetus may be poisoned *in utero* if lead from the mother's bones is subsequently mobilized by the changes in metabolism due to pregnancy; increased calcium intake in pregnancy may help mitigate this phenomenon.

Nervous system

Lead affects the peripheral nervous system (especially motor nerves) and the central nervous system. Peripheral nervous system effects are more prominent in adults and central nervous system effects are more prominent in children. Lead causes the axons of nerve cells to degenerate and lose their myelin coats.

Lead exposure in young children has been linked to learning disabilities, and children with blood lead concentrations greater than 10 µg/dL are in danger of developmental disabilities. Increased blood lead level in children has been correlated with decreases in intelligence, nonverbal reasoning, short-term memory, attention, reading and arithmetic ability, fine motor skills, emotional regulation, and social engagement.

The effect of lead on children's cognitive abilities takes place at very low levels. There is apparently no lower threshold to the dose-response relationship (unlike other heavy metals such as mercury). Reduced academic performance has been associated with lead exposure even at blood lead levels lower than 5 µg/dL. Blood lead levels below 10 µg/dL have been reported to be associated with lower IQ and behavior problems such as aggression, in proportion with blood lead levels. Between the blood lead levels of 5 and 35 µg/dL, an IQ decrease of 2–4 points for each µg/dL increase is reported in children. However, studies that show associations between low-level lead

exposure and health effects in children may be affected by confounding and overestimate the effects of low-level lead exposure.

High blood lead levels in adults are also associated with decreases in cognitive performance and with psychiatric symptoms such as depression and anxiety. It was found in a large group of current and former inorganic lead workers in Korea that blood lead levels in the range of 20–50 µg/dL were correlated with neuro-cognitive defects. Increases in blood lead levels from about 50 to about 100 µg/dL in adults have been found to be associated with persistent, and possibly permanent, impairment of central nervous system function.

Lead exposure in children is also correlated with neuropsychiatric disorders such as attention deficit hyperactivity disorder and anti-social behaviour. Elevated lead levels in children are correlated with higher scores on aggression and delinquency measures. A correlation has also been found between prenatal and early childhood lead exposure and violent crime in adulthood. Countries with the highest air lead levels have also been found to have the highest murder rates, after adjusting for confounding factors. A May 2000 study by economic consultant Rick Nevin theorizes that lead exposure explains 65% to 90% of the variation in violent crime rates in the US. A 2007 paper by the same author claims to show a strong association between preschool blood lead and subsequent crime rate trends over several decades across nine countries. Lead exposure in childhood appears to increase school suspensions and juvenile detention among boys. It is believed that the U.S. ban on lead paint in buildings in the late 1970s, as well as the phaseout of leaded gasoline in the 1970s and 1980s, partially helped contribute to the decline of violent crime in the United States since the early 1990s.

Exposure routes

Lead is a common environmental pollutant. Causes of environmental contamination include industrial use of lead, such as is found in facilities that process lead-acid batteries or produce lead wire or pipes, and metal recycling and foundries. Storage batteries and ammunition are made with the largest amounts of lead consumed in the economy each year, in the US as of 2013. Children living near facilities that process lead, such as lead smelters, have been found to have unusually high blood lead levels. In August 2009, parents rioted in China after lead poisoning was found in nearly 2000 children living near zinc and manganese smelters. Lead exposure can occur from contact with lead in air, household dust, soil, water, and commercial products. Leaded gasoline has also been linked to increases in lead pollution. Some research has suggested a link between leaded gasoline and crime rates. Man made lead pollution has been elevated in the air for the past 2000 years. Lead pollution in the air is entirely due to human activity (mining and smelting).

Occupational exposure

In adults, occupational exposure is the main cause of lead poisoning. People can be exposed when working in facilities that produce a variety of lead-containing products; these include radiation shields, ammunition, certain surgical equipment, developing dental x-ray films prior to digital x-rays (each film packet had a lead liner to prevent the radiation from going through), fetal monitors, plumbing, circuit boards, jet engines, and ceramic glazes. In addition, lead miners and smelters, plumbers and fitters, auto mechanics, glass manufacturers, construction workers, battery manufacturers and recyclers, firing range instructors, and plastic manufacturers are at risk for lead exposure. Other occupations that present lead exposure risks include welding, manufacture of rubber, printing, zinc and copper smelting, processing of ore, combustion of solid waste, and production of paints and pigments. Parents who are exposed to lead in the workplace can bring lead dust home on clothes or skin and expose their children. Occupational exposure to lead increases the risk of cardiovascular disease, in particular: stroke, and high blood pressure.

Food

Lead may be found in food when food is grown in soil that is high in lead, airborne lead contaminates the crops, animals eat lead in their diet, or lead enters the food either from what it was stored or cooked in.

Paint

Some lead compounds are colorful and are used widely in paints, and lead paint is a major route of lead exposure in children. A study conducted in 1998–2000 found that 38 million housing units in the US had lead-based paint, down from a 1990 estimate of 64 million. Deteriorating lead paint can produce dangerous lead levels in household dust and soil. Deteriorating lead paint and lead-containing household dust are the main causes of chronic lead poisoning. The lead breaks down into the dust and since children are more prone to crawling on the floor, it is easily ingested. Many young children display pica, eating things that are not food. Even a small amount of a lead-containing product such as a paint chip or a sip of glaze can contain tens or hundreds of milligrams of lead. Eating chips of lead paint presents a particular hazard to children, generally producing more severe poisoning than occurs from dust. Because removing lead paint from dwellings, e.g. by sanding or torching creates lead-containing dust and fumes, it is generally safer to seal the lead paint under new paint (excepting moveable windows and doors, which create paint dust when operated). Alternatively, special precautions must be taken if the lead paint is to be removed. In oil painting it was once common for colours such as yellow or white to be made with lead carbonate. Lead white oil colour was the main white of oil painters until superseded by compounds containing zinc or titanium in the mid-20th

century. It is speculated that the painter Caravaggio and possibly Francisco Goya and Vincent Van Gogh had lead poisoning due to overexposure or carelessness when handling this colour.

Soil

Residual lead in soil contributes to lead exposure in urban areas. It has been thought that the more polluted an area is with various contaminants, the more likely it is to contain lead. However, this is not always the case, as there are several other reasons for lead contamination in soil. Lead content in soil may be caused by broken-down lead paint, residues from lead-containing gasoline, used engine oil, tire weights, or pesticides used in the past, contaminated landfills, or from nearby industries such as foundries or smelters. Although leaded soil is less of a problem in countries that no longer have leaded gasoline, it remains prevalent, raising concerns about the safety of urban agriculture; eating food grown in contaminated soil can present a lead hazard.

Water

Lead from the atmosphere or soil can end up in groundwater and surface water. It is also potentially in drinking water, e.g. from plumbing and fixtures that are either made of lead or have lead solder. Since acidic water breaks down lead in plumbing more readily, chemicals can be added to municipal water to increase the pH and thus reduce the corrosivity of the public water supply. Chloramines, which were adopted as a substitute for chlorine disinfectants due to fewer health concerns, increase corrosivity. In the US, 14–20% of total lead exposure is attributed to drinking water. In 2004, a team of seven reporters from *The Washington Post* discovered high levels of lead in the drinking water in Washington, D.C. and won an award for investigative reporting for a series of articles about this contamination. In the Flint water crisis, a switch to a more corrosive municipal water source elevated lead levels in drinking water in domestic tap water.

Like Flint, Michigan and Washington, D.C., a similar fate had fallen on the State of Wisconsin, where they are estimated in having to replace up to 176,000 underground pipes due being made of lead. The city of Madison, Wisconsin addressed the issue and replaced all of their piping, but there are still others that have yet to follow suit. While there are chemical methods that could help reduce the amount of lead in the water distributed, the sure fix would be replacing the pipes completely. The problem with this solution is that while the state may replace the pipes below ground, it will be up to the homeowners to fix the pipes on their property which could end up being \$3,000 on average. Experts say that if the city were to replace their pipes and the citizens were to keep the old pipes located in their homes, there would be a potential for more lead to flow into their drinking water. The ultimate goal is for a total overhaul to take place, but this would require the citizens to buy into the pipe replacement. Such a move would allow the preservation of present health and secure greater health for the future.

Collecting rainwater from roof runoff used as potable water may contain lead if there are lead contaminants on the roof or in the storage tank. The Australian Drinking Water Guidelines allow a maximum of .01 mg/L lead in water.

Lead-containing products

Lead can be found in products such as kohl, an ancient cosmetic from the Middle East, South Asia, and parts of Africa that has many names; and from some toys. In 2007, millions of toys made in China were recalled from multiple countries owing to safety hazards including lead paint. Vinyl mini-blinds, found especially in older housing, may contain lead. Lead is commonly incorporated into herbal remedies such as Indian Ayurvedic preparations and remedies of Chinese origin. There are also risks of elevated blood lead levels caused by folk remedies like *azarcon* and *greta*, which each contain about 95% lead.

Ingestion of metallic lead, such as small lead fishing lures, increases blood lead levels and can be fatal. Ingestion of lead-contaminated food is also a threat. Ceramic glaze often contains lead, and dishes that have been improperly fired can leach the metal into food, potentially causing severe poisoning. In some places, the solder in cans used for food contains lead. When manufacturing medical instruments and hardware, solder containing lead may be present. People who eat animals hunted with lead bullets may be at risk for lead exposure. Bullets lodged in the body rarely cause significant levels of lead, but bullets lodged in the joints are the exception, as they deteriorate and release lead into the body over time.

In May 2015, Indian food safety regulators in the state of Uttar Pradesh found that samples of Maggi 2 Minute Noodles contained lead up to 17 times beyond permissible limits. On 3 June 2015, New Delhi Government banned the sale of Maggi noodles in New Delhi stores for 15 days because it was found to contain lead beyond the permissible limit. The Gujarat FDA on June 4, 2015 banned the noodles for 30 days after 27 out of 39 samples were detected with objectionable levels of metallic lead, among other things. Some India's biggest retailers like Future Group, Big Bazaar, Easyday and Nilgiris have imposed a nationwide ban on Maggi noodles. Many other states too have banned Maggi noodles.

Bullets

Contact with ammunition is a source of lead exposure. As of 2013, lead-based ammunition production is the second largest annual use of lead in the US, accounting for over 84,800 metric tons consumed in 2013, second only to the manufacture of storage batteries. The Environmental Protection Agency (EPA) cannot regulate cartridges and shells, as a matter of law. Lead birdshot is banned in some areas, but this is primarily for the benefit of the birds and their predators, rather than humans. Contamination

from heavily used gun ranges are of concern to those who live near by. Non-lead alternatives include steel, tungsten-nickel-iron, bismuth-tin, and tungsten-polymer.

Because game animals can be shot using lead bullets, the potential for lead ingestion from game meat consumption has been studied clinically and epidemiologically. In a recent study conducted by the CDC, a cohort from North Dakota was enrolled and asked to self-report historical consumption of game meat, and participation in other activities that could cause lead exposure. The study found that participants' age, sex, housing age, current hobbies with potential for lead exposure, and game consumption were all associated with blood lead level (PbB).

According to a study published in 2008, 1.1% of the 736 persons consuming wild game meat tested had PbB ≥ 5 $\mu\text{g/dl}$. In November 2015 The US HHS/CDC/NIOSH designated 5 $\mu\text{g/dL}$ (five micrograms per deciliter) of whole blood, in a venous blood sample, as the reference blood lead level for adults. An elevated BLL is defined as a BLL ≥ 5 $\mu\text{g/dL}$. This case definition is used by the ABLES program, the Council of State and Territorial Epidemiologists (CSTE), and CDC's National Notifiable Diseases Surveillance System (NNDSS). Previously (i.e. from 2009 until November 2015), the case definition for an elevated BLL was a BLL ≥ 10 $\mu\text{g/dL}$.

Copper-jacketed, lead-based bullets are more economical to produce and use than lead or any other material. Alternative materials are available such as steel, copper, and tungsten, but alternatives are universally less effective and/or more expensive. However, the biggest impediment to using the vast majority of alternatives relates to current laws in the United States pertaining to armor-piercing rounds. Laws and regulations relating to armor-piercing ammunition expressly prohibit the use of brass, bronze, steel, tungsten, and nearly every metallic alternative in any bullet that can be shot by a handgun, which at this time is nearly every caliber smaller than 50BMG (including the popular .223 Remington, .308 Winchester and .30-06 to name just a few). Some lead-based bullets are resistant to fragmentation, offering hunters the ability to clean game animals with negligible risk of including lead fragments in prepared meat. Other bullets are prone to fragmentation and exacerbate the risk of lead ingestion from prepared meat. In practice, use of a non-fragmenting bullet and proper cleaning of the game animal's wound can eliminate the risk of lead ingestion from eating game; however, isolating such practice to experimentally determine its association with blood lead levels in study is difficult. Bismuth is an element used as a lead-replacement for shotgun pellets used in waterfowl hunting although shotshells made from bismuth are nearly ten times the cost of lead (Lead poisoning).

ARSENIC POISONING

Arsenic poisoning is a medical condition that occurs due to elevated levels of arsenic in the body. If arsenic poisoning occurs over a brief period of time symptoms may include vomiting, abdominal

pain, encephalopathy, and watery diarrhea that contains blood. Long-term exposure can result in thickening of the skin, darker skin, abdominal pain, diarrhea, heart disease, numbness, and cancer.

The most common reason for long-term exposure is contaminated drinking water. Groundwater most often becomes contaminated naturally; however, contamination may also occur from mining or agriculture. It may also be found in the soil and air. Recommended levels in water are less than 10–50 µg/L (10–50 parts per billion). Other routes of exposure include toxic waste sites and traditional medicines. Most cases of poisoning are accidental. Arsenic acts by changing the functioning of around 200 enzymes. Diagnosis is by testing the urine, blood, or hair.

Prevention is by using water that does not contain high levels of arsenic. This may be achieved by the use of special filters or using rainwater. There is not good evidence to support specific treatments for long-term poisoning. For acute poisonings treating dehydration is important. Dimercaptosuccinic acid (DMSA) or dimercaptopropane sulfonate (DMPS) may be used while dimercaprol (BAL) is not recommended. Hemodialysis may also be used.

Through drinking water, more than 200 million people globally are exposed to higher than safe levels of arsenic. The areas most affected are Bangladesh and West Bengal. Exposure is also more common in people of low income and minorities. Acute poisoning is uncommon. The toxicity of arsenic has been described as far back as 1500 BC in the Ebers papyrus.

Signs and symptoms

Symptoms of arsenic poisoning begin with headaches, confusion, severe diarrhea, and drowsiness. As the poisoning develops, convulsions and changes in fingernail pigmentation called leukonychia striata (Mees's lines, or Aldrich-Mees's lines) may occur. When the poisoning becomes acute, symptoms may include diarrhea, vomiting, vomiting blood, blood in the urine, cramping muscles, hair loss, stomach pain, and more convulsions. The organs of the body that are usually affected by arsenic poisoning are the lungs, skin, kidneys, and liver. The final result of arsenic poisoning is coma and death.

Arsenic is related to heart disease (hypertension-related cardiovascular disease), cancer, stroke (cerebrovascular diseases), chronic lower respiratory diseases, and diabetes. Skin effects can include skin cancer in the long-term but often prior to skin cancer are different skin lesions. Other effects may include darkening of skin and thickening of skin.

Chronic exposure to arsenic is related to vitamin A deficiency, which is related to heart disease and night blindness. The acute minimal lethal dose of arsenic in adults is estimated to be 70 to 200 mg or 1 mg/kg/day.

Cancer

Arsenic increases the risk of cancer. Exposure is related to skin, lung, liver, and kidney cancer among others.

Its comutagenic effects may be explained by interference with base and nucleotide excision repair, eventually through interaction with zinc finger structures. Dimethylarsinic acid, DMA(V), caused DNA single strand breaks resulting from inhibition of repair enzymes at levels of 5 to 100 mM in human epithelial type II cells.

MMA(III) and DMA(III) were also shown to be directly genotoxic by effectuating scissions in supercoiled Φ X174 DNA. Increased arsenic exposure is associated with an increased frequency of chromosomal aberrations, micronuclei and sister-chromatid exchanges. An explanation for chromosomal aberrations is the sensitivity of the protein tubulin and the mitotic spindle to arsenic. Histological observations confirm effects on cellular integrity, shape and locomotion.

DMA(III) is able to form reactive oxygen species (ROS) by reaction with molecular oxygen. Resulting metabolites are the dimethylarsenic radical and the dimethylarsenic peroxy radical. Both DMA(III) and DMA(V) were shown to release iron from horse spleen as well as from human liver ferritin if ascorbic acid was administered simultaneously. Thus, formation of ROS can be promoted. Moreover, arsenic could cause oxidative stress by depleting the cell's antioxidants, especially the ones containing thiol groups. The accumulation of ROS like the cited above and hydroxyl radicals, superoxide radicals and hydrogen peroxides causes aberrant gene expression at low concentrations and lesions of lipids, proteins and DNA in higher concentrations which eventually lead to cellular death. In a rat animal model, urine levels of 8-hydroxy-2'-desoxyguanosine (as a biomarker of ROS DNA damage) were measured after treatment with DMA(V). In comparison to control levels, they turned out to be significantly increased. This theory is further supported by a cross-sectional study which found elevated mean serum lipid peroxides (LPO) in the As exposed individuals which correlated with blood levels of inorganic arsenic and methylated metabolites and inversely correlated with nonprotein sulfhydryl (NPSH) levels in whole blood. Another study found an association of As levels in whole blood with the level of reactive oxidants in plasma and an inverse relationship with plasma antioxidants. A finding of the latter study indicates that methylation might in fact be a detoxification pathway with regard to oxidative stress: the results showed that the lower the As methylation capacity was, the lower the level of plasma antioxidant capacity. As reviewed by Kitchin (2001), the oxidative stress theory provides an explanation for the preferred tumor sites connected with arsenic exposure. Considering that a high partial pressure of oxygen is present in lungs and DMA(III) is excreted in gaseous state via the lungs this seems to be a plausible mechanism for special

vulnerability. The fact that DMA is produced by methylation in the liver, excreted via the kidneys and latter on stored in the bladder accounts for the other tumor localizations.

Regarding DNA methylation, some studies suggest interaction of As with methyltransferases which leads to an inactivation of tumor suppressor genes through hypermethylation, others state that hypomethylation might occur due to a lack of SAM resulting in aberrant gene activation. An experiment by Zhong et al. (2001) with arsenite-exposed human lung A549, kidney UOK123, UOK109 and UOK121 cells isolated eight different DNA fragments by methylation-sensitive arbitrarily primed PCR. It turned out that six of the fragments were hyper- and two of them were hypomethylated. Higher levels of DNA methyltransferase mRNA and enzyme activity were found.

Kitchin (2001) proposed a model of altered growth factors which lead to cell proliferation and thus to carcinogenesis. From observations, it is known that chronic low-dose arsenic poisoning can lead to increased tolerance to its acute toxicity. MRP1-overexpressing lung tumor GLC4/Sb30 cells poorly accumulate arsenite and arsenate. This is mediated through MRP-1 dependent efflux. The efflux requires GSH, but no As-GSH complex formation.

Although many mechanisms have been proposed, no definite model can be given for the mechanisms of chronic arsenic poisoning. The prevailing events of toxicity and carcinogenicity might be quite tissue-specific. Current consensus on the mode of carcinogenesis is that it acts primarily as a tumor promoter. Its co-carcinogenicity has been demonstrated in several models. However, the finding of several studies that chronically arsenic-exposed Andean populations (as most extremely exposed to UV-light) do not develop skin cancer with chronic arsenic exposure, is puzzling.

Causes

Organic arsenic is less harmful than inorganic arsenic. Seafood is a common source of the less toxic organic arsenic in the form of arsenobetaine. The arsenic reported in 2012 in fruit juice and rice by *Consumer Reports* was primarily inorganic arsenic. Because of its high toxicity, arsenic is seldom used in the Western world, although in Asia it is still a popular pesticide. Arsenic is mainly encountered occupationally in the smelting of zinc and copper ores.

Drinking water

Arsenic is naturally found in groundwater and presents serious health threats when high amounts exist. Chronic arsenic poisoning results from drinking contaminated well water over a long period of time. Many aquifers contain high concentration of arsenic salts. The World Health Organization (WHO) Guidelines for drinking water quality established in 1993 a provisional guideline value of 0.01 mg/L (10 parts per billion) for maximum contaminant levels of arsenic in drinking water. This

recommendation was established based on the limit of detection for most laboratories' testing equipment at the time of publication of the WHO water quality guidelines. More recent findings show that consumption of water with levels as low as 0.00017 mg/L (0.17 parts per billion) over long periods of time can lead to arsenicosis.

From a 1988 study in China, the US protection agency quantified the lifetime exposure of arsenic in drinking water at concentrations of 0.0017 mg/L (1.7 ppb), 0.00017 mg/L, and 0.000017 mg/L are associated with a lifetime skin cancer risk of 1 in 10,000, 1 in 100,000, and 1 in 1,000,000 respectively. WHO asserts that a water level of 0.01 mg/L (10 ppb) poses a risk of 6 in 10000 chance of lifetime skin cancer risk and contends that this level of risk is acceptable.

One of the worst incidents of arsenic poisoning via well water occurred in Bangladesh, which the World Health Organization called the "largest mass poisoning of a population in history" recognized as a major public health concern. The contamination in the Ganga- Brahmaputra fluvial plains in India and Padma-Meghna fluvial plains in Bangladesh demonstrated adverse impacts on human health.

Mining techniques such as hydraulic fracturing may mobilize arsenic in groundwater and aquifers due to enhanced methane transport and resulting changes in redox conditions, and inject fluid containing additional arsenic.

Groundwater

In the US, the U.S. Geological Survey estimates that the median groundwater concentration is 1 µg/L or less, although some groundwater aquifers, particularly in the western United States, can contain much higher levels. For example, median levels in Nevada were about 8 µg/L but levels of naturally occurring arsenic as high as 1000 µg/L have been measured in the United States in drinking water.

Geothermally active zones occur at hotspots where mantle-derived plumes ascend, such as in Hawaii and Yellowstone National Park, USA. Arsenic is an incompatible element (do not fit easily into the lattices of common rock-forming minerals). Concentrations of arsenic are high mainly in geothermal waters that leach continental rocks. Arsenic in hot geothermal fluids was shown to be derived mainly from leaching of host rocks at Yellowstone National Park, in Wyoming, USA, rather than from magmas.

In the western USA, there are As (arsenic) inputs to groundwater and surface water from geothermal fluids in and near Yellowstone National Park, and in other western mineralized areas. Groundwater associated with volcanics in California contain As at concentrations ranging up to 48,000 µg/L, with As-bearing sulfide minerals as the main source. Geothermal waters on Dominica in the Lesser Antilles also contain concentrations of As >50 µg/L.

In general, because arsenic is an incompatible element, it accumulates in differentiated magmas, and in other western mineralized areas. Weathering of pegmatite veins in Connecticut, USA, was thought to contribute As to groundwater.

In Pennsylvania, As concentrations in water discharging from abandoned anthracite mines ranged from <0.03 to 15 µg/L and from abandoned bituminous mines, from 0.10 to 64 µg/L, with 10% of samples exceeding the United States Environmental Protection Agency MLC of 10 µg/L/

In Wisconsin, As concentrations of water in sandstone and dolomite aquifers were as high as 100 µg/L. Oxidation of pyrite hosted by these formations was the likely source of the As.

In the Piedmont of Pennsylvania and New Jersey, groundwater in Mesozoic age aquifers contains elevated levels of As—domestic well waters from Pennsylvania contained up to 65 µg/L, whereas in New Jersey the highest concentration measured recently was 215 µg/L.

Food

In the United States, Schoof et al. (1999) estimated an average adult intake of 3.2 µg/day, with a range of 1–20 µg/day. Estimates for children were similar.

Food also contains many organic arsenic compounds. The key organic arsenic compounds that can be routinely found in food (depending on food type) include monomethylarsonic acid (MMAsV), Dimethylearsenoic acid (DMAsV), arsenobetaine, arsenocholine, arsenosugars, and arsenolipids. DMAsV or MMAsV can be found in various types of fin fish, crabs, and mollusks, but often at very low levels.

Arsenobetaine is the major form of arsenic in marine animals, and, by all accounts, it is considered a compound that is nontoxic under conditions of human consumption. Arsenocholine, which is mainly found in shrimp, is chemically similar to arsenobetaine, and is considered to be “essentially nontoxic”. Although arsenobetaine is little studied, available information indicates it is not mutagenic, immunotoxic, or embryotoxic.

Arsenosugars and arsenolipids have recently been identified. Exposure to these compounds and toxicological implications are currently being studied. Arsenosugars are detected mainly in seaweed but are also found to a lesser extent in marine mollusks. Studies addressing arsenosugar toxicity, however, have largely been limited to in vitro studies, which show that arsenosugars are significantly less toxic than both inorganic arsenic and trivalent methylated arsenic metabolites.

It has been found that rice is particularly susceptible to accumulation of arsenic from soil. Rice grown in the U.S. has an average 260 ppb of arsenic, according to a study; but U.S. arsenic intake remains

far below World Health Organization-recommended limits. China has set a standard for arsenic limits in food (150 ppb), as levels in rice exceed those in water.

Arsenic is a ubiquitous element present in American drinking water. In the United States, levels of arsenic that are above natural levels, but still well below danger levels set in federal safety standards, have been detected in commercially raised chickens. The source of the arsenic appears to be the feed additives roxarsone and nitarsone, which are used to control the parasitic infection coccidiosis as well as to increase weight and skin coloring of the poultry.

High levels of inorganic arsenic were reportedly found in 83 California wines in 2015.

Soil

Exposure to arsenic in soil can occur through multiple pathways. Compared with the intake of naturally occurring arsenic from water and the diet, soil arsenic constitutes only a small fraction of intake.

Air

The European Commission (2000) reports that levels of arsenic in air range 0–1 ng/m³ in remote areas, 0.2–1.5 ng/m³ in rural areas, 0.5–3 ng/m³ in urban areas, and up to about 50 ng/m³ in the vicinity of industrial sites. Based on these data, the European Commission (2000) estimated that in relation to food, cigarette smoking, water, and soil, air contributes less than 1% of total arsenic exposure.

Pesticides

The use of lead arsenate pesticides has been effectively eliminated for over 50 years. However, because of the pesticide's environmental persistence, it is estimated that millions of acres of land are still contaminated with lead arsenate residues. This presents a potentially significant public health concern in some areas of the United States (e.g., New Jersey, Washington, and Wisconsin), where large areas of land used historically as orchards have been converted into residential developments.

Some modern uses of arsenic-based pesticides still exist. Chromated copper arsenate (CCA) has been registered for use in the United States since the 1940s as a wood preservative, protecting wood from insects and microbial agents. In 2003, CCA manufacturers instituted a voluntary recall of residential uses of CCA-treated wood. the EPA 2008 final report stated that CCA is still approved for use in nonresidential applications, such as in marine facilities (pilings and structures), utility poles, and sand highway structures.

Copper smelting

Exposure studies in the copper smelting industry are much more extensive and have established definitive links between arsenic, a by-product of copper smelting, and lung cancer via inhalation. Dermal and neurological effects were also increased in some of these studies. Although as time went on, occupational controls became more stringent and workers were exposed to reduced arsenic concentrations, the arsenic exposures measured from these studies ranged from about 0.05 to 0.3 mg/m³ and are significantly higher than airborne environmental exposures to arsenic (which range from 0 to 0.000003 mg/m³) (Arsenic poisoning).

FLUORIDE TOXICITY

Fluoride toxicity is a condition in which there are elevated levels of the fluoride ion in the body. Although fluoride is safe for dental health at low concentrations, sustained consumption of large amounts of soluble fluoride salts is dangerous. Referring to a common salt of fluoride, sodium fluoride (NaF), the lethal dose for most adult humans is estimated at 5 to 10 g (which is equivalent to 32 to 64 mg/kg elemental fluoride/kg body weight). Ingestion of fluoride can produce gastrointestinal discomfort at doses at least 15 to 20 times lower (0.2–0.3 mg/kg or 10 to 15 mg for a 50 kg person) than lethal doses. Although it is helpful topically for dental health in low dosage, chronic ingestion of fluoride in large amounts interferes with bone formation. In this way, the most widespread examples of fluoride poisoning arise from consumption of ground water that is abnormally fluoride-rich.

Recommended levels

For optimal dental health, the World Health Organization recommends a level of fluoride from 0.5 to 1.0 mg/L (milligrams per liter), depending on climate. Fluorosis becomes possible above this recommended dosage. As of 2015, the United States Health and Human Services Department recommends a maximum of 0.7 milligrams of fluoride per liter of water – updating and replacing the previous recommended range of 0.7 to 1.2 milligrams issued in 1962. The new recommended level is intended to reduce the occurrence of dental fluorosis while maintaining water fluoridation.

Toxicity

Chronic

In India an estimated 60 million people have been poisoned by well water contaminated by excessive fluoride, which is dissolved from the granite rocks. The effects are particularly evident in the bone deformities of children. Similar or larger problems are anticipated in other countries including China, Uzbekistan, and Ethiopia.

Acute

Historically, most cases of acute fluoride toxicity have followed accidental ingestion of sodium fluoride based insecticides or rodenticides. Currently, in advanced countries, most cases of fluoride exposure are due to the ingestion of dental fluoride products. Other sources include glass-etching or chrome-cleaning agents like ammonium bifluoride or hydrofluoric acid, industrial exposure to fluxes used to promote the flow of a molten metal on a solid surface, volcanic ejecta (for example, in cattle grazing after an 1845–1846 eruption of Hekla and the 1783–1784 flood basalt eruption of Laki), and metal cleaners. Malfunction of water fluoridation equipment has happened several times, including a notable incident in Alaska.

Occurrence

Organofluorine compounds

Twenty percent of modern pharmaceuticals contain fluorine. These organofluorine compounds are not sources of fluoride poisoning. The carbon–fluorine bond is too strong to release fluoride.

Fluoride in toothpaste

Children may experience gastrointestinal distress upon ingesting excessive amounts of flavored toothpaste. Between 1990 and 1994, over 628 people, mostly children, were treated after ingesting too much fluoride-containing toothpaste. "While the outcomes were generally not serious," gastrointestinal symptoms appear to be the most common problem reported. However given the low concentration of fluoride present in dental products, this is potentially due to consumption of other major components.

Fluoride in drinking water

Around one-third of the world's population drinks water from groundwater resources. Of this, about 10 percent, approximately 300 million people, obtains water from groundwater resources that are heavily contaminated with arsenic or fluoride. These trace elements derive mainly from leaching of minerals. Maps are available of locations of potential problematic wells via the Groundwater Assessment Platform (GAP).

Effects

Excess fluoride consumption has been studied as a factor in the following:

Brain

Some research has suggested that high levels of fluoride exposure may adversely affect neuro development in children, but the evidence is of insufficient quality to allow any firm conclusions to be drawn.

Bones

Whilst fluoridated water is associated with decreased levels of fractures in a population, toxic levels of fluoride have been associated with a weakening of bones and an increase in hip and wrist fractures. The U.S. National Research Council concludes that fractures with fluoride levels 1–4 mg/L, suggesting a dose-response relationship, but states that there is "suggestive but inadequate for drawing firm conclusions about the risk or safety of exposures at [2 mg/L]".

Consumption of fluoride at levels beyond those used in fluoridated water for a long period of time causes skeletal fluorosis. In some areas, particularly the Asian subcontinent, skeletal fluorosis is endemic. It is known to cause irritable-bowel symptoms and joint pain. Early stages are not clinically obvious, and may be misdiagnosed as (seronegative) rheumatoid arthritis or ankylosing spondylitis.

Kidney

Fluoride induced nephrotoxicity is kidney injury due to toxic levels of serum fluoride, commonly due to release of fluoride from fluorine-containing drugs, such as methoxyflurane.

Within the recommended dose, no effects are expected, but chronic ingestion in excess of 12 mg/day are expected to cause adverse effects, and an intake that high is possible when fluoride levels are around 4 mg/L. Those with impaired kidney function are more susceptible to adverse effects.

The kidney injury is characterised by failure to concentrate urine, leading to polyuria, and subsequent dehydration with hypernatremia and hyperosmolarity. Inorganic fluoride inhibits adenylate cyclase activity required for antidiuretic hormone effect on the distal convoluted tubule of the kidney. Fluoride also stimulates intrarenal vasodilation, leading to increased medullary blood flow, which interferes with the counter current mechanism in the kidney required for concentration of urine.

Fluoride induced nephrotoxicity is dose dependent, typically requiring serum fluoride levels exceeding 50 micromoles per liter (about 1 ppm) to cause clinically significant renal dysfunction, which is likely when the dose of methoxyflurane exceeds 2.5 MAC hours. (Note: "MAC hour" is the multiple of the minimum alveolar concentration (MAC) of the anesthetic used times the number of hours the drug is administered, a measure of the dosage of inhaled anesthetics.)

Elimination of fluoride depends on glomerular filtration rate. Thus, patients with renal insufficiency will maintain serum fluoride for longer period of time, leading to increased risk of fluoride induced nephrotoxicity.

Teeth

The only generally accepted adverse effect of fluoride at levels used for water fluoridation is dental fluorosis, which can alter the appearance of children's teeth during tooth development; this is mostly mild and usually only an aesthetic concern. Compared to unfluoridated water, fluoridation to 1 mg/L is estimated to cause fluorosis in one of every 6 people (range 4–21), and to cause fluorosis of aesthetic concern in one of every 22 people (range 13.6–∞).

Thyroid

Fluoride's suppressive effect on the thyroid is more severe when iodine is deficient, and fluoride is associated with lower levels of iodine. Thyroid effects in humans were associated with fluoride levels 0.05–0.13 mg/kg/day when iodine intake was adequate and 0.01–0.03 mg/kg/day when iodine intake was inadequate. Its mechanisms and effects on the endocrine system remain unclear.

Effects on aquatic organisms

Fluoride accumulates in the bone tissues of fish and in the exoskeleton of aquatic invertebrates. The mechanism of fluoride toxicity in aquatic organisms is believed to involve the action of fluoride ions as enzymatic poisons. In soft waters with low ionic content, invertebrates and fishes may suffer adverse effects from fluoride concentration as low as 0.5 mg/L. Negative effects are less in hard waters and seawaters, as the bioavailability of fluoride ions is reduced with increasing water hardness. Seawater contains fluoride at a concentration of 1.3 mg/L (Fluoride toxicity).

2.7 SELF-ASSESSMENT TEST

- Distinguish between hazard and disaster. Discuss the different types of hazards.
- Defining vulnerability. Discuss about risk assessment.
- What are the causes of Tsunami? Discuss about the warnings and predictions of tsunami.
- Discuss about the causes and consequences of plastic pollution.
- Discuss the mechanism of tropical cyclone. Discuss the prediction, precaution and mitigation measures of tropical cyclone.

2.8 SUMMARIES AND KEY POINTS

The present section introduces the concept and types of hazards and disasters. It discusses regarding assessment of risk and vulnerability. It highlights the concepts of hazard and disaster management. Climatic hazards: Tropical cyclones (prediction, precaution and mitigation), Marine/ tectonic hazard: Tsunami (prediction, precaution and mitigation) Hydrological hazards: Flash floods in Himalayan region and floods in southern part of West Bengal. It discusses the sources, impacts and mitigation measures of nuclear hazard, radio-active contamination, CFC, plastic hazard, lead, arsenic and fluoride contaminations

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Disclaimer: This self-learning material is based on different books, journals and web-sources.