A Comprehensive Study of
Geography

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VIDYA BOOKS

Published by Vidya Books,
305, Ajit Bhawan,
21 Ansari Road,
Daryaganj, Delhi 110002

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ISBN: 978-93-5429-026-8

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Introduction

Traditionally, geographers have been viewed the same way as cartographers and people who study place names and numbers. Although many geographers are trained in toponymy and cartology, this is not their main preoccupation. Geographers study the spatial and temporal distribution of phenomena, processes and features as well as the interaction of humans and their environment. As space and place affect a variety of topics such as economics, health, climate, plants and animals, geography is highly interdisciplinary.

"Mere names of places...are not geography...know by heart a whole gazetteer full of them would not, in itself, constitute anyone a geographer. Geography has higher aims than this: it seeks to classify phenomena (alike of the natural and of the political world, in so far as it treats of the latter), to compare, to generalize, to ascend from effects to causes, and, in doing so, to trace out the great laws of nature and to mark their influences upon man. This is 'a description of the world'—that is Geography. In a word Geography is a Science—a thing not of mere names but of argument and reason, of cause and effect." — *William Hughes, 1863*

Geography as a discipline can be split broadly into two main subsidiary fields: human geography and physical geography. The former focuses largely on the built environment and how space is created, viewed and managed by humans as well as the influence humans have on the space they occupy. The latter examines the natural environment and how the climate, vegetation & life, soil, water, and landforms are produced and interact. As a result of the two subfields using different approaches a third field has emerged, which is environmental geography. Environmental geography combines physical and human geography and looks at the interactions between the environment and humans.

BRANCHES OF GEOGRAPHY

Physical Geography

Physical geography (or physiography) focuses on geography as an Earth science. It aims to understand the physical lithosphere, hydrosphere, atmosphere, pedosphere, and global flora and fauna patterns (biosphere). Physical geography can be divided into the following broad categories:

- Biogeography
- Climatology & paleoclimatology
- Coastal geography Env. geog. & management
- Geodesy
- Geomorphology
- Glaciology
- Hydrology & Hydrography
- Landscape ecology Oceanography
- Pedology
- Palaeogeography
- Quaternary science

Human Geography

Human geography is a branch of geography that focuses on the study of patterns and processes that shape human interaction with various environments. It encompasses human, political, cultural, social, and economic aspects.

While the major focus of human geography is not the physical landscape of the Earth, it is hardly possible to discuss human geography without referring to the physical landscape on which human activities are being played out, and environmental geography is emerging as a link between the two. Human geography can be divided into many broad categories, such as:

- Cultural geography

- Development geography
- Economic geography Health geography
- Historical & Time geog.
- Political geog. & Geopolitics
- Pop. geog. or Demography
- Religion geography
- Social geography
- Transportation geography
- Tourism geography
- Urban geography

Various approaches to the study of human geography have also arisen through time and include:

- Behavioral geography
- Feminist geography
- Culture theory
- Geosophy

Environmental Geography

Environmental geography is the branch of geography that describes the spatial aspects of interactions between humans and the natural world. It requires an understanding of the traditional aspects of physical and human geography, as well as the ways in which human societies conceptualize the environment.

Environmental geography has emerged as a bridge between human and physical geography as a result of the increasing specialisation of the two sub-fields. Furthermore, as human relationship with the environment has changed as a result of globalization and technological change a new approach was needed to understand the changing and dynamic relationship. Examples of areas of research in environmental geography include emergency management, environmental management, sustainability, and political ecology.

Geomatics

Geomatics is a branch of geography that has emerged since the quantitative revolution in geography in the mid 1950s. Geomatics involves the use of traditional spatial techniques used in cartography and topography and their application to computers. Geomatics has become a widespread field with many other disciplines using techniques such as GIS and remote sensing. Geomatics has also led to a revitalization of some geography departments especially in Northern America where the subject had a declining status during the 1950s.

Geomatics encompasses a large area of fields involved with spatial analysis, such as Cartography, Geographic information systems (GIS), Remote sensing, and Global positioning systems (GPS).

Regional Geography

Regional geography is a branch of geography that studies the regions of all sizes across the Earth. It has a prevailing descriptive character. The main aim is to understand or define the uniqueness or character of a particular region which consists of natural as well as human elements. Attention is paid also to regionalization which covers the proper techniques of space delimitation into regions. Regional geography is also considered as a certain approach to study in geographical sciences.

Related Fields

Urban planning, regional planning and spatial planning: use the science of geography to assist in determining how to develop (or not develop) the land to meet particular criteria, such as safety, beauty, economic opportunities, the preservation of the built or natural heritage, and so on. The planning of towns, cities, and rural areas may be seen as applied geography.

Regional science: In the 1950s the regional science movement led by Walter Isard arose, to provide a more quantitative and analytical base to geographical questions, in contrast to the descriptive tendencies of traditional geography programs. Regional science comprises the body of knowledge in which the spatial dimension plays a fundamental role, such as regional economics, resource management, location theory, urban and regional planning, transport and communication, human geography, population distribution, landscape ecology, and environmental quality.

Interplanetary Sciences: While the discipline of geography is normally concerned with the Earth, the term can also be informally used to describe the study of other worlds, such as the planets of the Solar System and even beyond. The study of systems larger than the earth itself usually forms part of Astronomy or Cosmology. The study of other planets is usually called planetary science. Alternative terms such as Areology (the study of Mars) have been proposed, but are not widely used.

Geographical Techniques

As spatial interrelationships are key to this synoptic science, maps are a key tool. Classical cartography has been joined by a more modern approach to geographical analysis, computer-based geographic information systems (GIS).

In their study, geographers use four interrelated approaches:

- Systematic-Groups geographical knowledge into categories that can be explored globally.
- Regional-Examines systematic relationships between categories for a specific region or location on the planet.
- Descriptive-Simply specifies the locations of features and populations.
- Analytical-Asks *why* we find features and populations in a specific geographic area.

Cartography

Cartography studies the representation of the Earth's surface with abstract symbols (map making). Although other subdisciplines of geography rely on maps for presenting their analyses, the actual making of maps is abstract enough to be regarded separately.

Cartography has grown from a collection of drafting techniques into an actual science. Cartographers must learn cognitive psychology and ergonomics to understand which symbols convey information about the Earth most effectively, and behavioral psychology to induce the readers of their maps to act on the information.

They must learn geodesy and fairly advanced mathematics to understand how the shape of the Earth affects the distortion of map symbols projected onto a flat surface for viewing. It can be said, without much controversy, that cartography is the seed from which the larger field of geography grew. Most geographers will cite a childhood fascination with maps as an early sign they would end up in the field.

Geographic Information Systems

Geographic information systems (GIS) deal with the storage of information about the Earth for automatic retrieval by a computer, in an accurate manner appropriate to the information's purpose. In addition to all of the other subdisciplines of geography, GIS specialists must understand computer science and database systems. GIS has revolutionized the field of cartography; nearly all mapmaking is now done with the assistance of some form of GIS software. GIS also refers to the science of using GIS software and GIS techniques to represent, analyze and predict spatial relationships. In this context, GIS stands for Geographic Information Science.

Remote Sensing

Remote sensing is the science of obtaining information about Earth features from measurements made at a distance. Remotely sensed data comes in many forms such as satellite imagery, aerial photography and data obtained from hand-held sensors. Geographers increasingly use remotely sensed data to obtain information about the Earth's land surface, ocean and atmosphere because it: a) supplies objective information at a variety of spatial scales (local to global), b) provides a synoptic view of the area of interest, c) allows access to distant and/or inaccessible sites, d) provides spectral information outside the visible portion of the electromagnetic spectrum, and e) facilitates studies of how features/areas change over time. Remotely sensed data may be analyzed either independently of, or in conjunction with, other digital data layers (e.g., in a Geographic Information System).

Geographic Quantitative Methods

Geostatistics deal with quantitative data analysis, specifically the application of statistical methodology to the exploration of geographic phenomena. Geostatistics is used extensively in a variety of fields including: hydrology, geology, petroleum exploration, weather analysis, urban planning, logistics, and epidemiology. The mathematical basis for geostatistics derives from cluster analysis, linear discriminant analysis and non-parametric statistical tests, and a variety of other subjects. Applications of geostatistics rely heavily on geographic information systems, particularly for the interpolation (estimate) of unmeasured points. Geographers are making notable contributions to the method of quantitative techniques.

Geographic Qualitative Methods

Geographic qualitative methods, or ethnographical; research techniques, are used by human geographers. In cultural geography there is a tradition of employing qualitative research techniques also used in anthropology and sociology. Participant observation and in-depth interviews provide human geographers with qualitative data.

HISTORY OF GEOGRAPHY

The oldest known world maps date back to ancient Babylon from the 9th century BC. The best known Babylonian world map, however, is the *Imago Mundi* of 600 BC. The map as reconstructed by Eckhard Unger shows Babylon on the Euphrates, surrounded by a circular landmass showing Assyria, Urartu and several cities, in turn surrounded by a "bitter river" (Oceanus), with seven islands arranged around it so as to form a seven-pointed star. The accompanying text mentions seven outer regions beyond the encircling ocean. The descriptions of five of them have survived. In contrast to the *Imago Mundi*, an earlier Babylonian world map dating back to the 9th century BC depicted Babylon as being further north from the centre of the world, though it is not certain what that centre was supposed to represent.

The ideas of Anaximander (c. 610 B.C.-c. 545 B.C.), considered by later Greek writers to be the true founder of geography, come to us through fragments quoted by his successors. Anaximander is credited with the invention of the gnomon,the simple yet efficient Greek instrument that allowed the early measurement of latitude. Thales, Anaximander is also credited with the prediction of eclipses. The foundations of geography can be traced to the ancient cultures, such as the ancient, medieval, and early modern Chinese. The Greeks, who were the first to explore geography as both art and science, achieved this through Cartography, Philosophy, and Literature, or through Mathematics. There is some debate about who was the first person to assert that the Earth is spherical in shape, with the credit going either to Parmenides or Pythagoras. Anaxagoras was able to demonstrate that the profile of the Earth was circular by explaining eclipses. However, he still believed that the Earth was a flat disk, as did many of his contemporaries. One of the first estimates of the radius of the Earth was made by Eratosthenes.

The first rigorous system of latitude and longitude lines is credited to Hipparchus. He employed a sexagesimal system that was derived from Babylonian mathematics. The parallels and meridians were sub-divided into 360°, with each degree further subdivided 602 (minutes). To measure the longitude at different location on Earth, he suggested using eclipses to determine the relative difference in time. The extensive mapping by the Romans as they explored new lands would later provide a high level of information for Ptolemy to construct detailed atlases. He extended the work of Hipparchus, using a grid system on his maps and adopting a length of 56.5 miles for a degree.

From the 3rd century onwards, Chinese methods of geographical study and writing of geographical literature became much more complex than what was found in Europe at the time (until the 13th century). Chinese geographers such as Liu An, Pei Xiu, Jia Dan, Shen Kuo, Fan Chengda, Zhou Daguan, and Xu Xiake wrote important treatises, yet by the 17th century, advanced ideas and methods of Western-style geography were adopted in China.

During the Middle Ages, the fall of the Roman empire led to a shift in the evolution of geography from Europe to the Islamic world. Muslim geographers such as Muhammad al-Idrisi produced detailed world maps (such as Tabula Rogeriana), while other geographers such as Yaqut al-Hamawi, Abu Rayhan Biruni, Ibn Battuta and Ibn Khaldun provided detailed accounts of their journeys and the geography of the regions they visited. Turkish geographer, Mahmud al-Kashgari drew a world map on a linguistic basis, and later so did Piri Reis (Piri Reis map).

Further, Islamic scholars translated and interpreted the earlier works of the Romans and Greeks and established the House of Wisdom in Baghdad for this purpose. Abu Zayd al-Balkhi, originally from Balkh, founded the "Balkhi school" of terrestrial mapping in Baghdad.

Suhrab, a late tenth century Muslim geographer, accompanied a book of geographical coordinates with instructions for making a rectangular world map, with equirectangular projection or cylindrical equidistant projection. In the early 11th century, Avicenna hypothesized on the geological causes of mountains in *The Book of Healing* (1027).

Abu Rayhan Biruni (976-1048) first described a polar equi-azimuthal equidistant projection of the celestial sphere. He was regarded as the most skilled when it came to mapping cities and measuring the distances between them, which he did for many cities in the Middle East and Indian subcontinent. He often combined astronomical readings and mathematical equations, in order to develop methods of pin-pointing locations by recording degrees of latitude and longitude.

He also developed similar techniques when it came to measuring the heights of mountains, depths of valleys, and expanse of the horizon. He also discussed human geography and the planetary habitability of the Earth. He hypothesized that roughly a quarter of the Earth's surface is habitable by humans.

He also calculated the latitude of Kath, Khwarezm, using the maximum altitude of the Sun, and solved a complex geodesic equation in order to accurately compute the Earth's circumference, which were close to modern values of the Earth's circumference. His estimate of 6,339.9 km for the Earth radius was only 16.8 km less than the modern value of 6,356.7 km.

In contrast to his predecessors who measured the Earth's circumference by sighting the Sun simultaneously from two different locations, al-Biruni developed a new method of using trigonometric calculations based on the angle between a plain and mountain top which yielded more accurate measurements of the Earth's circumference and made it possible for it to be measured by a single person from a single location. He also published a study of map projections, *Cartography*, which included a method for projecting a hemisphere on a plane.

The European Age of Discovery during the 16th and 17th centuries, where many new lands were discovered and accounts by European explorers such as Christopher Columbus, Marco Polo and James Cook, revived a desire for both accurate geographic detail, and more solid theoretical foundations in Europe. The problem facing both explorers and geographers was finding the latitude and longitude of a geographic location.

The problem of latitude was solved long ago but that of longitude remained; agreeing on what zero meridian should be was only part of the problem. It was left to John Harrison to solve it by inventing the chronometer H-4, in 1760, and later in 1884 for the International Meridian Conference to adopt by convention the Greenwich meridian as zero meridian.

The 18th and 19th centuries were the times when geography became recognized as a discrete academic discipline and became part of a typical university curriculum in Europe (especially Paris and Berlin). The development of many geographic societies also occurred during the 19th century with the foundations of the Society de Geography in 1821, the Royal Geographical Society in 1830, Russian Geographical Society in 1845, American Geographical Society in 1851, and the National Geographic Society in 1888.

The influence of Immanuel Kant, Alexander von Humboldt, Carl Ritter and Paul Vidal de la Blache can be seen as a major turning point in geography from a philosophy to an academic subject.

Over the past two centuries the advancements in technology such as computers, have led to the development of geomatics and new practices such as participant observation and geostatistics being incorporated into geography's portfolio of tools. In the West during the 20th century, the discipline of geography went through four major phases: environmental determinism, regional geography, the quantitative revolution, and critical geography. The strong interdisciplinary links between geography and the sciences of geology and botany, as well as economics, sociology and demographics have also grown greatly especially as a result of Earth System Science that seeks to understand the world in a holistic view.

Notable Geographers

- Eratosthenes (276BC-194BC)-calculated the size of the Earth.
- Ptolemy (c.90–c.168)-compiled Greek and Roman knowledge into the book Geographia.
- Al Idrisi (1100–1165/66)-author of Nuzhatul Mushtaq.
- Gerardus Mercator (1512–1594)-innovative cartographer produced the mercator projection.
- Alexander von Humboldt (1769–1859)-Considered Father of modern geography, published the Kosmos and founder of the sub-field biogeography.
- Carl Ritter (1779–1859)-Considered Father of modern geography. Occupied the first chair of geography at Berlin University.
- Arnold Henry Guyot (1807–1884)-noted the structure of glaciers and advanced understanding in glacier motion, especially in fast ice flow.
- William Morris Davis (1850–1934)-father of American geography and developer of the cycle of erosion.
- Paul Vidal de la Blache (1845–1918)-founder of the French school of geopolitics and wrote the principles of human geography.
- Sir Halford John Mackinder (1861–1947)-Co-founder of the LSE, Geographical Association.
- Carl O. Sauer (1889–1975)-Prominent cultural geographer.
- Walter Christaller (1893–1969)-human geographer and inventor of Central place theory.
- Yi-Fu Tuan (1930-)-Chinese-American scholar credited with starting Humanistic Geography as a discipline.
- David Harvey (1935-)-Marxist geographer and author of theories on spatial and urban geography, winner of the Vautrin Lud Prize.
- Edward Soja (born 1941)-Noted for his work on regional development, planning and governance along with coining the terms Synekism and Postmetropolis.

- Michael Frank Goodchild (1944-)-prominent GIS scholar and winner of the RGS founder's medal in 2003.
- Doreen Massey (1944-)-Key scholar in the space and places of globalization and its pluralities, winner of the Vautrin Lud Prize.
- Nigel Thrift (1949-)-originator of non-representational theory.

Geographical Institutions and Societies

- Anton Melik Geographical Institute (Slovenia)
- National Geographic Society (U.S.)
- American Geographical Society (U.S.)
- National Geographic Bee (U.S.)
- Royal Canadian Geographical Society (Canada)
- Royal Geographical Society (UK)

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Physical Geography

Physical geography (also known as geosystems or physiography) is one of the two major subfields of geography. Physical geography is that branch of natural science which deals with the study of processes and patterns in the natural environment like atmosphere, biosphere and geosphere, as opposed to the cultural or built environment, the domain of human geography.

Within the body of physical geography, the Earth is often split either into several spheres or environments, the main spheres being the atmosphere, biosphere, cryosphere, geosphere, hydrosphere, lithosphere and pedosphere. Research in physical geography is often interdisciplinary and uses the systems approach.

Fields of Physical Geography

Geomorphology is the science concerned with understanding the surface of the Earth and the processes by which it is shaped, both at the present as well as in the past. Geomorphology as a field has several sub-fields that deal with the specific landforms of various environments e.g. desert geomorphology and fluvial geomorphology, however, these sub-fields are united by the core processes which cause them; mainly tectonic or climatic processes. Geomorphology seeks to understand landform history and dynamics, and predict future changes through a combination of field observation, physical experiment, and numerical modelling. (Geomorphometry). Early studies in geomorphology are the foundation for pedology, one of two main branches of soil science. Hydrology is predominantly concerned with the amounts and quality of water moving and accumulating on the land surface and in the soils and rocks near the surface and is typified by the hydrological cycle. Thus the field encompasses water in rivers, lakes, aquifers and to an extent glaciers, in which the field examines the process and dynamics involved in these bodies of water. Hydrology has historically had an important connection with engineering and has thus developed a largely quantitative method in its research; however, it does have an earth science side that embraces the systems approach. Similar to most fields of physical geography it has sub-fields that examine the specific bodies of water or their interaction with other spheres e.g. limnology and ecohydrology.

Glaciology is the study of glaciers and ice sheets, or more commonly the cryosphere or ice and phenomena that involve ice. Glaciology groups the latter (ice sheets) as continental glaciers and the former (glaciers) as alpine glaciers. Although, research in the areas are similar with research undertaken into both the dynamics of ice sheets and glaciers the former tends to be concerned with the interaction of ice sheets with the present climate and the latter with the impact of glaciers on the landscape. Glaciology also has a vast array of sub-fields examining the factors and processes involved in ice sheets and glaciers e.g. snow hydrology and glacial geology.

Biogeography is the science which deals with geographic patterns of species distribution and the processes that result in these patterns. Biogeography emerged as a field of study as a result of the work of Alfred Russel Wallace, although the field prior to the late twentieth century had largely been viewed as historic in its outlook and descriptive in its approach. The main stimulus for the field since its founding has been that of evolution, plate tectonics and the theory of island biogeography. The field can largely be divided into five sub-fields: island biogeography, paleobiogeography, phylogeography, zoogeography and phytogeography.

Climatology is the study of the climate, scientifically defined as weather conditions averaged over a long period of time. It differs from meteorology, which studies atmospheric processes over a shorter duration, which are then examined by climatologists to find trends and frequencies in weather patterns/ phenomena. Climatology examines both the nature of micro (local) and macro (global) climates and the natural and anthropogenic influences on them. The field is also sub-divided largely into the climates of various regions and the study of specific phenomena or time periods e.g. tropical cyclone rainfall climatology and paleoclimatology.

Pedology is the study of soils in their natural environment. It is one of two main branches of soil science, the other being edaphology. Pedology mainly deals with pedogenesis, soil morphology, soil classification. In physical geography pedology is largely studied due to the numerous interactions between climate (water, air, temperature), soil life (micro-organisms, plants, animals), the mineral materials within soils (biogeochemical cycles) and its position and effects on the landscape such as laterization.

Palaeogeography is the study of the distribution of the continents through geologic time through examining the preserved material in the stratigraphic record. Palaeogeography is a cross-discipline, almost all the evidence for the positions of the continents comes from geology in the form of fossils or geophysics the use of this data has resulted in evidence for continental drift, plate tectonics and super continents this in turn has supported palaeogeographic theories such as the Wilson cycle.

Coastal geography is the study of the dynamic interface between the ocean and the land, incorporating both the physical geography (i.e coastal geomorphology, geology and oceanography) and the human geography of the coast. It involves an understanding of coastal weathering processes, particularly wave action, sediment movement and weathering, and also the ways in which humans interact with the coast. Coastal geography although predominantly geomorphological in its research is not just concerned with coastal landforms, but also the causes and influences of sea level change.

Oceanography is the branch of physical geography that studies the Earth's oceans and seas. It covers a wide range of topics, including marine organisms and ecosystem dynamics (biological oceanography); ocean currents, waves, and geophysical fluid dynamics (physical oceanography); plate tectonics and the geology of the sea floor (geological oceanography); and fluxes of various chemical substances and physical properties within the ocean and across its boundaries (chemical oceanography).

These diverse topics reflect multiple disciplines that oceanographers blend to further knowledge of the world ocean and understanding of processes within it.

Quaternary science is an inter-disciplinary field of study focusing on the Quaternary period, which encompasses the last 2.6 million years. The field studies the last ice age and the recent interstadial the Holocene and uses proxy evidence to reconstruct the past environments during this period to infer the climatic and environmental changes that have occurred.

Landscape ecology is a sub-discipline of ecology and geography that address how spatial variation in the landscape affects ecological processes such as the distribution and flow of energy, materials and individuals in the environment (which, in turn, may influence the distribution of landscape “elements” themselves such as hedgerows). The field was largely founded by the German geographer Carl Troll Landscape ecology typically deals with problems in an applied and holistic context.

The main difference between biogeography and landscape ecology is that the latter is concerned with how flows or energy and material are changed and their impacts on the landscape whereas the former is concerned with the spatial patterns of species and chemical cycles.

Geomatics is the field of gathering, storing, processing, and delivering of geographic information, or spatially referenced information. Geomatics includes geodesy (scientific discipline that deals with the measurement and representation of the earth, its gravitational field, and other geodynamic phenomena, such as crustal motion, oceanic tides, and polar motion) and G.I.S. (a system for capturing, storing, analyzing and managing data and associated attributes which are spatially referenced to the earth) and remote sensing (the short or large-scale acquisition of information of an object or phenomenon, by the use of either recording or real-time sensing devices that are not in physical or intimate contact with the object).

Environmental geography is a branch of geography that analyzes the spatial aspects of interactions between humans and the natural world. The branch bridges the divide between human and physical geography and thus requires an understanding of the dynamics of geology, meteorology, hydrology, biogeography, and geomorphology, as well as the ways in which human societies conceptualize the environment.

Although the branch was previously more visible in research than at present with theories such as environmental determinism linking society with the environment. It has largely become the domain of the study of environmental management or anthropogenic influences on the environment and vice a versa.

Physical Geography Literature

Physical geography and Earth Science journals communicate and document the results of research carried out in universities and various other research institutions. Most journals cover a specific field and publish the research within that field, however unlike human geographers, physical geographers tend to publish in inter-disciplinary journals rather than predominantly geography journal; the research is normally expressed in the form of a scientific paper.

Additionally, textbooks, books, and magazines on geography communicate research to laypeople, although these tend to focus on environmental issues or cultural dilemmas.

HISTORIC EVOLUTION OF PHYSICAL GEOGRAPHY

From the birth of geography as a science during the Greek classical period and until the late nineteenth century with the birth of anthropography or Human Geography, Geography was almost exclusively a natural science: the study of location and descriptive gazetteer of all places of the known world. Several works among the best known during this long period could be cited as an example, from Strabo (Geography), Eratosthenes (Geography) or Dionisio Periegetes (Periegesis Oiceumene) in the Ancient Age to the Alexander von Humboldt (Cosmos) in the century XIX, in which geography is regarded as a physical and natural science, of course, through the work Summa de Geografia of Martin Fernandez de Enciso from the early sixteenth century, which is indicated for the first time the New World.

During the eighteenth and nineteenth centuries, a controversy exported from Geology, between supporters of James Hutton (uniformitarianism Thesis) and Georges Cuvier (catastrophism) strongly influenced the field of geography, because geography at this time was a natural science since Human Geography or Antropogeography had just developed as a discipline in the late nineteenth century.

Two historical events during the nineteenth century had a great effect in the further development of physical geography. The first was the European colonial expansion in Asia, Africa, Australia and even America in search of raw materials required by industries during the Industrial Revolution. This fostered the creation of geography departments in the universities of the colonial powers and the birth and development of national geographical societies, thus giving rise to the process identified by Horacio Capel as the institutionalization of geography.

One of the most prolific empires in this regard was the Russian. A mid-eighteenth century many geographers are sent by the Russian altamirazgo different opportunities to perform geographical surveys in the area of Arctic Siberia. Among these is who is considered the patriarch of Russian geography: Mikhail Lomonosov who in the mid-1750s began working in the Department of Geography, Academy of Sciences to conduct research in Siberia, their contributions are notable in this regard, shows the soil organic origin, develops a comprehensive law on the movement of the ice that still governs the basics, thereby founding a new branch of Geography: Glaciology. In 1755 his initiative was founded Moscow University where he promotes the study of geography and the training of geographers. In 1758 he was appointed director of the Department of Geography, Academy of Sciences, a post from which would develop a working methodology for geographical survey guided by the most important long expeditions and geographical studies in Russia.

Thus followed the line of Lomonosov and the contributions of the Russian school became more frequent through his disciples, and in the nineteenth century we have great geographers as Vasily Dokuchaev who performed works of great importance as a "principle of comprehensive analysis of the territory" and "Russian Chernozem" latter being the most important where introduces the geographical concept of soil, as distinct from a simple geological strata, and thus founding a new geographic area of study: the Pedology. Climatology also receive a strong boost from the Russian school by Wladimir Koppen whose main contribution, climate classification, is still valid today.

However, this great geographer also contributed to the Paleogeography through his work "The climates of the geological past" which is considered the father of Paleoclimatology. Russian geographers who made great contributions to the discipline in this period were: NM Sibirtsev, Pyotr Semyonov, K. D. Glinka, Neustrayev, among others.

The second important process is the theory of evolution by Darwin in mid-century (which decisively influenced the work of Ratzel, who had academic training as a zoologist and was a follower of Darwin's ideas) which meant an important impetus in the development of Biogeography.

Another major event in the late nineteenth and early twentieth century will give a major boost to development of geography and will take place in United States. It is the work of the famous geographer William Morris Davis who not only made important contributions to the establishment of discipline in his country, but revolutionized the field to develop geographical cycle theory which he proposed as a paradigm for Geography in general, although in actually served as a paradigm for Physical Geography. His theory explained that mountains and other landforms are shaped by the influence of a number of factors that are manifested in the geographical cycle. He explained that the cycle begins with the lifting of the relief by geological processes (faults, volcanism, tectonic upheaval, etc.).. Geographical factors such as rivers and runoff begins to create the V-shaped valleys between the mountains (the stage called "youth").

During this first stage, the terrain is steeper and more irregular. Over time, the currents can carve wider valleys ("maturity") and then start to wind, towering hills only ("senescence"). Finally, everything comes to what is a plain flat plain at the lowest elevation possible (called "baseline") This plain was called by Davis' "peneplain" meaning "almost plain" Then the rejuvenation occurs and there is another mountain lift and the cycle continues.

Although Davis's theory is not entirely accurate, it was absolutely revolutionary and unique in its time and helped to modernize and create Geography subfield of Geomorphology. Its implications prompted a myriad of research in various branches of Physical Geography. In the case of the Paleogeography this theory provided a model for understanding the evolution of the landscape. For Hydrology, Glaciology and Climatology as a boost investigated as studying geographic factors shape the landscape and affect the cycle.

The bulk of the work of William Morris Davis led to the development of a new branch of Physical Geography: Geomorphology whose contents until then did not differ from the rest of Geography. Shortly after this branch would present a major development. Some of his disciples made significant contributions to various branches of physical geography such as Curtis Marbut and his invaluable legacy for Pedology, Mark Jefferson, Isaiah Bowman, among others.

PHYSIOGRAPHIC REGIONS OF THE WORLD

The physiographic regions of the world are a means of defining the Earth's landforms into distinct regions based upon Nevin Fenneman's classic three-tiered approach of divisions, provinces and sections, in 1916, which although they date from the mid 1910s, are still considered basically valid, and were the basis for similar classifications of other continents later. These works have been termed "Indespensible to any student of physiography are the maps and physiographic diagrams by Fenneman, Lobeck, Raisz, and Hammond".

During the early 1900s, the study of regional-scale geomorphology was termed "physiography". Unfortunately, physiography later was considered to be a contraction of "*physi*cal" and "ge*ography*", and therefore synonymous with physical geography, and the concept became embroiled in controversy surrounding the appropriate concerns of that discipline. Some geomorphologists held to a geological basis for physiography and emphasized a concept of physiographic regions while a conflicting trend among geographers was to equate physiography with "pure morphology," separated from its geological heritage. In current usage, physiography still lends itself to confusion as to which meaning is meant, the more specialized "geomorphological" definition or the more encompassing "physical geography" definition. For the remainder of this article, emphasis will remain on the more "geomorphological" usage, which is based upon geological landforms, not on climate, vegetation, or other non-geological criteria.

For the purposes of physiographic mapping, landforms are classified according to both their geologic structures and histories. Distinctions based on geologic age also correspond to physiographic distinctions where the forms are so recent as to be in their first erosion cycle, as is generally the case with sheets of glacial drift. Generally, forms which result from similar histories are characterized by certain similar features, and differences in history result in corresponding differences of form, usually resulting in distinctive features which are obvious to the casual observer, but this is not always the case. A maturely dissected plateau may grade without a break from rugged mountains on the one hand to mildly rolling farm lands on the other. So also, forms which are not classified together may be superficially similar; for example, a young coastal plain and a peneplain. In a large number of cases, the boundary lines are also geologic lines, due to differences in the nature or structure of the underlying rocks.

History

The history of "physiography" itself is at best a complicated effort. Much of the complications arise from how the term has evolved over time, both as its own 'science' and as a synonym for other branches of science. In 1848, Mary Somerville published her book *Physical Geography* which gave detailed descriptions of the topography of each continent, along with the distribution of plant, animals and humans. This work gave impetus to further works along the field. In Germany, Oscar Peschel in 1870, proposed that geographers should study the morphology of the Earth's surface, having an interest in the study of landforms for the development of human beings. As the chair of geography (and a geologist by training) in Bonn, Germany, Ferdinand von Richtofen made the study of landforms the main research field for himself and his students. Elsewhere, Thomas Henry Huxley's *Physiography* was published in 1877 in Britain. Shortly after, the field of "physical geography" itself was renamed as "physiography". Afterwards, physiography became a very popular school subject in Britain, accounting for roughly 10% of all examination papers in both English and Welsh schools, and physiography was now regarded as an integral, if not the most important aspect of geography.

In conjunction with these 'advances' in physiography, physically and visually mapping these descriptive areas was underway as well. The early photographers and balloonists, Nadar and Triboulet, experimented with aerial photography and the view it provided of the landscape. In 1899, Albert Heim published his photographs and observations made during a balloon flight over the Alps; he is probably the first person to use aerial photography in geomorphological or physiographical research. The block diagrams of Feeneman, Raisz, Lobeck and many others were based in part upon both aerial photography and topographic maps, giving an oblique "birds-eye" view. By 1901, there were clear differences in the definition of the term physiography. "In England, physiography is regarded as the introduction to physical science in general. It is made to include the elements of physics, chemistry, astronomy, physical geography, and geology, and sometimes even certain phases of botany and zoology. In America, the term has a somewhat different meaning. It is sometimes used as a synonym for physical geography, and is sometimes defined as the science which describes and explains the physical features of the earth's surface".

By 1911, the definition of physiography in *Encyclopaedia Britannica* had evolved to be "In popular usage the words 'physical geography' have come to mean geography viewed from a particular standpoint rather than any special department of the subject. The popular Physical meaning is better conveyed by the word physiography, a geography term which appears to have been introduced by Linnaeus, and was reinvented as a substitute for the cosmography of the Middle Ages by Professor Huxley. Although the term has since been limited by some writers to one particular part of the subject, it seems best to maintain the original and literal meaning. In the stricter sense, physical geography is that part of geography which involves the processes of contemporary change in the crust and the circulation of the fluid envelopes. It thus draws upon physics for the explanation of the phenomena with the space-relations of which it is specially concerned. Physical geography naturally falls into three divisions, dealing respectively with the surface of the lithosphere-geomorphology; the hydrosphere-oceanography; and the atmosphere-climatology. All these rest upon the facts of mathematical geography, and the three are so closely inter-related that they cannot be rigidly separated in any discussion".

The 1919 edition of *The Encyclopedia Americana: A Library of Universal Knowledge* further adjusted the definition to be "Physiography (geomorphology), now generally recognized as a science distinct from geology, deals with the origins and development of land forms, traces out the topographic expression of structure, and embodies a logical history of oceanic basins, and continental elevations; of mountains, plateaus and plains; of hills and valleys. Physical geography is used loosely as a synonym, but the term is more properly applied to the borderland between geography and physiography; dealing, as it does, largely with the human element as influenced by its physiographic surroundings".

Even in the 21st century, some confusion remains as to exactly what "physiography" is. One source states "Geomorphology includes quaternary geology, physiography and most of physical geography", treating physiography as a separate field, but subservient to geomorphology. Another source states "Geomorphology (or physiography) refers to the study of the surface features of the earth. It involves looking at the distribution of land, water, soil and rock material that forms the land surface. Land is closely linked to the geomorphology of a particular landscape", regarding physiography as synonymous with geomorphology. Yet another source states "Physiography may be viewed from two distinct angles, the one dynamic, the other passive". The same source continues by stating "In a large fashion geodynamics is intimately associated with certain branches of geology, as sedimentation, while geomorphology connects physiography with geography. The dynamic interlude representing the active phase of physiography weaves the basic threads of geologic history." The U.S. Geological Survey defines physiography as a study of "Features and attributes of earth's land surface", while geomorphology is defined separately as "Branch of geology dealing with surface land features and the processes that create and change them".

Partly due to this confusion over what "physiography" actually means, some scientists have refrained from using the term physiography (and instead use the similar term geomorphology) because the definitions vary from the American Geological Institute's "the study and classification of the surface features of Earth on the basis of similarities in geologic structure and the history of geologic changes" to descriptions that also include vegation and/or land use.

PHYSICAL EVIDENCE FOR CLIMATIC CHANGE

Evidence for climatic change is taken from a variety of sources that can be used to reconstruct past climates. Reasonably complete global records of surface temperature are available beginning from the mid-late 1800s. For earlier periods, most of the evidence is indirect—climatic changes are inferred from changes in proxies, indicators that reflect climate, such as vegetation, ice cores, dendrochronology, sea level change, and glacial geology.

Historical and Archaeological Evidence

Climate change in the recent past may be detected by corresponding changes in settlement and agricultural patterns. Archaeological evidence, oral history and historical documents can offer insights into past changes in the climate. Climate change effects have been linked to the collapse of various civilisations.

Glaciers

Glaciers are considered among the most sensitive indicators of climate change, advancing when climate cools and retreating when climate warms. Glaciers grow and shrink, both contributing to natural variability and amplifying externally forced changes. A world glacier inventory has been compiled since the 1970s, initially based mainly on aerial photographs and maps but now relying more on satellites. This compilation tracks more than 100,000 glaciers covering a total area of approximately 240,000 km^2, and preliminary estimates indicate that the remaining ice cover is around 445,000 km^2. The World Glacier Monitoring Service collects data annually on glacier retreat and glacier mass balance From this data, glaciers worldwide have been found to be shrinking significantly, with strong glacier retreats in the 1940s, stable or growing conditions during the 1920s and 1970s, and again retreating from the mid 1980s to present.

The most significant climate processes since the middle to late Pliocene (approximately 3 million years ago) are the glacial and interglacial cycles. The present interglacial period (the Holocene) has lasted about 11,700 years. Shaped by orbital variations, responses such as the rise and fall of continental ice sheets and significant sea-level changes helped create the climate. Other changes, including Heinrich events, Dansgaard–Oeschger events and the Younger Dryas, however, illustrate how glacial variations may also influence climate without the orbital forcing.

Glaciers leave behind moraines that contain a wealth of material—including organic matter, quartz, and potassium that may be dated—recording the periods in which a glacier advanced and retreated. Similarly, by tephrochronological techniques, the lack of glacier cover can be identified by the presence of soil or volcanic tephra horizons whose date of deposit may also be ascertained.

Vegetation

A change in the type, distribution and coverage of vegetation may occur given a change in the climate; this much is obvious. In any given scenario, a mild change in climate may result in increased precipitation and warmth, resulting in improved plant growth and the subsequent sequestration of airborne CO_2. Larger, faster or more radical changes, however, may well result in vegetation stress, rapid plant loss and desertification in certain circumstances.

Ice Cores

Analysis of ice in a core drilled from a ice sheet such as the Antarctic ice sheet, can be used to show a link between temperature and global sea level variations. The air trapped in bubbles in the ice can also reveal the CO_2 variations of the atmosphere from the distant past, well before modern environmental influences. The study of these ice cores has been a significant indicator of the changes in CO_2 over many millennia, and continues to provide valuable information about the differences between ancient and modern atmospheric conditions.

Dendroclimatology

Dendroclimatology is the analysis of tree ring growth patterns to determine past climate variations. Wide and thick rings indicate a fertile, well-watered growing period, whilst thin, narrow rings indicate a time of lower rainfall and less-than-ideal growing conditions.

Pollen Analysis

Palynology is the study of contemporary and fossil palynomorphs, including pollen. Palynology is used to infer the geographical distribution of plant species, which vary under different climate conditions. Different groups of plants have pollen with distinctive shapes and surface textures, and since the outer surface of pollen is composed of a very resilient material, they resist decay. Changes in the type of pollen found in different sedimentation levels in lakes, bogs or river deltas indicate changes in plant communities; which are dependent on climate conditions.

Sea Level Change

Global sea level change for much of the last century has generally been estimated using tide gauge measurements collated over long periods of time to give a long-term average. More recently, altimeter measurements — in combination with accurately determined satellite orbits — have provided an improved measurement of global sea level change.

3

Environmentalism Geography

INTRODUCTION

Those of us who are children of the environmental movement must never forget that we are standing on the shoulders of all those who came before us.

The clean water we drink, the clean air we breathe, and the protected wilderness we treasure are all, in no small part, thanks to them. The two of us have worked for most of the country's leading environmental organizations as staff or consultants. We hold a sincere and abiding respect for our parents and elders in the environmental community. They have worked hard and accomplished a great deal. For that we are deeply grateful.

At the same time, we believe that the best way to honour their achievements is to acknowledge that modern environmentalism is no longer capable of dealing with the world's most serious ecological crisis.

Over the last 15 years environmental foundations and organizations have invested hundreds of millions of dollars into combating global warming. We have strikingly little to show for it. From the battles over higher fuel efficiency for cars and trucks to the attempts to reduce carbon emissions through international treaties, environmental groups repeatedly have tried and failed to win national legislation that would reduce the threat of global warming. As a result, people in the environmental movement today find themselves politically less powerful than we were one and a half decades ago.

Yet in lengthy conversations, the vast majority of leaders from the largest environmental organizations and foundations in the country insisted to us that we are on the right track. Nearly all of the more than two-dozen environmentalists we interviewed underscored that climate change demands that we remake the global economy in ways that will transform the lives of six billion people. All recognize that it's an undertaking of monumental size and complexity. And all acknowledged that we must reduce emissions by up to 70 percent as soon as possible.

But in their public campaigns, not one of America's environmental leaders is articulating a vision of the future commensurate with the magnitude of the crisis. Instead they are promoting technical policy fixes like pollution controls and higher vehicle mileage standards — proposals that provide neither the popular inspiration nor the political alliances the community needs to deal with the problem.

By failing to question their most basic assumptions about the problem and the solution, environmental leaders are like generals fighting the last war – in particular the war they fought and won for basic environmental protections more than 30 years ago. It was then that the community's political strategy became defined around using science to define the problem as "environmental" and crafting technical policy proposals as solutions.

The greatest achievements to reduce global warming are today happening in Europe. Britain has agreed to cut carbon emissions by 60 percent over 50 years, Holland by 80 percent in 40 years, and Germany by 50 percent in 50 years. Russia may soon ratify Kyoto. And even China – which is seen fearfully for the amount of dirty coal it intends to burn – recently established fuel economy standards for its cars and trucks that are much tougher than ours in the US.

Environmentalists are learning all the wrong lessons from Europe. We closely scrutinize the *policies* without giving much thought to the *politics* that made the policies possible. Our thesis is this: the environmental community's narrow definition of its self-interest leads to a kind of policy literalism that undermines its power. When you look at the long string of global warming defeats under Presidents Bill Clinton and George W. Bush, it is hard not to conclude that the environmental movement's approach to problems and policies hasn't worked particularly well. And yet there is nothing about the behaviour of environmental groups, and nothing in our interviews with environmental leaders, that indicates that we as a community are ready to think differently about our work.

What the environmental movement needs more than anything else right now is to take a collective step back to rethink everything. We will never be able to turn things around as long as we understand our failures as essentially tactical, and make proposals that are essentially technical. In Part II we make the case for what could happen if progressives created new institutions and proposals around a big vision and a core set of values. Much of this section is aimed at showing how a more powerful movement depends on letting go of old identities, categories and assumptions, so that we can be truly open to embracing a better model.

We resisted the exhortations from early reviewers of this report to say more about what we think must now be done because we believe that the most important next steps will emerge from teams, not individuals. Over the coming months we will be meeting with existing and emerging teams of practitioners and funders to develop a common vision and strategy for moving forward. One tool we have to offer to that process is the research we are doing as part of our Strategic Values Project, which is adapting corporate marketing research for use by the progressive community. This project draws on a 600 question, 2,500-person survey done in the U.S. and Canada every four years since 1992. In contrast to conventional opinion research, this research identifies the core values and beliefs that inform how individuals develop a range of opinions on everything from the economy. The Death of Environmentalism to abortion to what's the best SUV on the market. This research both shows a clear conservative shift in America's values since 1992 and illuminates many positive openings for progressives and environmentalists.

We believe that this new values science will prove to be invaluable in creating a road map to guide the development of a set of proposals that simultaneously energizes our base, wins over new allies, divides our opponents, achieves policy victories and makes America's values environment more progressive. Readers of this report who are interested in learning more about the Strategic Values Project — and want to engage in a dialogue about the future of environmentalism and progressive politics — should feel welcome to contact us.

ENVIRONMENTAL GROUPTHINK

If we wish our civilization to survive we must break with the habit of deference to great men. — Karl Popper

One of the reasons environmental leaders can whistle past the graveyard of global warming politics is that the membership rolls and the income of the big environmental organizations have grown enormously over the past 30 years — especially since the election of George W. Bush in 2000. The institutions that define what environmentalism means boast large professional staffs and receive tens of millions of dollars every year from foundations and individuals. Given these rewards, it's no surprise that most environmental leaders neither craft nor support proposals that could be tagged "non-environmental." Doing otherwise would do more than threaten their status; it would undermine their brand.

Environmentalists are particularly upbeat about the direction of public opinion thanks in large part to the polling they conduct that shows wide support for their proposals. Yet America is a vastly more right-wing country than it was three decades ago. The domination of American politics by the far-right is a central obstacle to achieving action on global warming. Yet almost none of the environmentalists we interviewed thought to mention it.

Part of what's behind America's political turn to the right is the skill with which conservative think tanks, intellectuals and political leaders have crafted proposals that build their power through setting the terms of the debate. Their work has paid off. According to a survey of 1,500 Americans by the market research firm Environics, the number of Americans who agree with the statement, "To preserve people's jobs in this country, we must accept higher levels of pollution in the future," increased from 17 percent in 1996 to 26 percent in 2000. The number of Americans who agreed that, "Most of the people actively involved in environmental groups are extremists, not reasonable people," leapt from 32 percent in 1996 to 41 percent in 2000.

The truth is that for the vast majority of Americans, the environment never makes it into their top ten list of things to worry about. Protecting the environment is indeed supported by a large majority — *it's just not supported very strongly*. Once you understand this, it's much easier to understand why it's been so easy for anti-environmental interests to gut 30 years of environmental protections. The conventional criticism of the environmental movement articulated by outsiders and many funders is that it is too divided to get the job done. Pulitzer Prizewinning journalist Ross Gelbspan argues in his new book *Boiling Point*, "Despite occasional spasms of cooperation, the major environmental groups have been unwilling to join together around a unified climate agenda, pool resources, and mobilize a united campaign on the climate."

Yet what was striking to us in our research was the high degree of consensus among environmental leaders about what the problems and solutions are. We came away from our interviews less concerned about internal divisions than the lack of feedback mechanisms.

Engineers use a technical term to describe systems without feedback mechanisms: "stupid." As individuals, environmental leaders are anything but stupid. Many hold multiple advanced degrees in science, engineering, and law from the best schools in the country. But as a community, environmentalists suffer from a bad case of group think, starting with shared assumptions about what we mean by "the environment" – a category that reinforces the notions that a) the environment is a separate "thing" and b) human beings are separate from and superior to the "natural world." The concepts of "nature" and "environment" have been thoroughly deconstructed. Yet they retain their mythic and debilitating power within the environmental movement and the public at large. If one understands the notion of the "environment" to include humans, then the way the environmental community designates certain problems as environmental and others as not is completely arbitrary. Why, for instance, is a *human*-made phenomenon like global warming — which may kill hundreds of millions of *human beings* over the next century — considered "environmental"? Why are poverty and war not considered environmental problems while global warming is? What are the implications of framing global warming as an *environmental* problem – and handing off the responsibility for dealing with it to "environmentalists"?

Some believe that this framing is a political, and not just conceptual, problem. "When we use the term 'environment' it makes it seem as if the problem is 'out there' and we need to 'fixit,'" said Susan Clark, Executive Director of the Columbia Foundation, who believes the Environmental Grantmakers Association should change its name. "The problem is not external to us; it's us. It's a human problem having to do with how we organize our society. This old way of thinking isn't anyone's fault, but it is all of our responsibility to change."

Not everyone agrees. "We need to remember that we're the environmental movement and that our job is to protect the environment," said the Sierra Club's Global Warming Director, Dan Becker. "If we stray from that, we risk losing our focus, and there's no one else to protect the environment if we don't do it. We're not a union or the Labour Department. Our job is to protect the environment, not to create an industrial policy for the United States. That doesn't mean we don't care about protecting workers."

Most environmentalists don't think of "the environment" as a mental category at all — they think of it as a real "thing" to be protected and defended. They think of themselves, literally, as representatives and defenders of this thing.

Environmentalists do their work as though these are literal rather than figurative truths. They tend to see language in general as representative rather than constitutive of reality. This is typical of liberals who are, at their core, children of the enlightenment who believe that they arrived at their identity and politics through a rational and considered process. They expect others in politics should do the same and are constantly surprised and disappointed when they don't. The effect of this orientation is a certain *literal-sclerosis* — the belief that social change happens only when people speak a literal "truth to power." Literal-sclerosis can be seen in the assumption that to win action on global warming one must talk about global warming instead of, say, the economy, industrial policy, or health care. "If you want people to act on global warming" stressed Becker, "you need to convince them that action is needed on global warming and not on some ulterior goal."

EVERYBODY LOSES ON FUEL EFFICIENCY

Great doubt: great awakening. Little doubt: little awakening. No doubt: no awakening. — Zen koan

By the end of the 1990s, environmentalists hadn't just failed to win a legislative agreement on carbon, they had also let a deal on higher vehicle fuel efficiency standards slip through their fingers. Since the 1970s environmentalists have defined the problem of oil dependency as a consequence of inadequate fuel efficiency standards. Their strategy has rested on trying to overpower industry and labour unions on environmental and national security grounds. The result has been massive failure: over the last 20 years, as automobile technologies have improved exponentially, *overall mileage rates have gone down, not up*.

Few beat around the bush when discussing this fact. "If the question is whether we've done anything to address the problem since 1985, the answer is no," said Bob Nordhaus, the Washington, D.C. attorney who served as General Counsel for the Department of Energy under President Clinton and who helped draft the Corporate Average Fuel Economy or "CAFE" (pronounced "cafe") legislation and the Clean Air Act. (Nordhaus is also the father of one of the authors of this report.) The first CAFE amendment in 1975 grabbed the low-hanging fruit of efficiency to set into place standards that experts say were much easier for industry to meet than the standards environmentalists are demanding now. The UAW and automakers agreed to the 1975 CAFE amendment out of a clearly defined self-interest: to slow the advance of Japanese imports.

"CAFE [in 1975] was backed by the UAW and [Michigan Democrat Rep. John] Dingell," said Shelly Fiddler, who was Chief of Staff for former Rep. Phil Sharp who authored the CAFE amendment before becoming Chief of Staff for the Clinton White House's Council on Environmental Quality. "It got done by Ford and a bunch of renegade staffers in Congress, not by environmentalists. The environmental community didn't originate CAFE and they had serious reservations about it."

Thanks to action by US automakers and inaction by US environmental groups, CAFE's efficiency gains stalled in the mid-1980s. It's not clear who did more damage to CAFE, the auto industry, the UAW or the environmental movement.

Having gathered 59 votes – one short of what's needed to stop a filibuster — Senator Richard Bryan nearly passed legislation to raise fuel economy standards in 1990. But one year later, when Bryan had a very good shot at getting the 60 votes he needed, the environmental movement cut a deal with the automakers. In exchange for the auto industry's opposition to drilling in the Arctic National Wildlife Refuge, environmentalists agreed to drop its support for the Bryan bill. "[I]t was skippered by the environmentalists, of all people, " *New York Times* auto industry reporter Keith Bradsher notes bitterly.

Tragically, had Bryan and environmentalists succeeded in 1991, they would have dramatically slowed the rise of SUVs in the coming decade and reduced the pressure on the Refuge — a patch of wilderness that the Republicans again used to smack around environmentalists under President George W. Bush. The environmental community's failure in 1991 was compounded by the fact that the Bryan bill "helped scare Japanese automakers into producing larger models," a shift that ultimately diminished the power of both the UAW and environmentalists.

"Where was the environmental movement?" asks Bradsher in his marvellous history of the SUV, *High and Mighty*. "[A]s a slow and steady transformation began taking place on the American road, the environmental movement stayed silent on SUVs all the way into the mid-1990s, and did not campaign in earnest for changes to SUV regulations until 1999." Finally, in 2002, Senator John Kerry and Senator John McCain popped up with another attempt to raise CAFE standards. Once again environmentalists failed to negotiate a deal with UAW. As a result, the bill lost by a far larger margin than it had in 1990. The Senate voted 62 – 38 to kill it. From the perspective of even the youngest and greenest Hill staffer, the political power of environmental groups appeared at an all-time low.

Environmental spokespersons tried to position their 2002 loss as a victory, arguing that it provided them with momentum going forward. But privately almost every environmental leader we interviewed told us that CAFE — in its 2002 incarnation— is dead.

Given CAFE's initial 10 years of success, from the mid-1970s to the mid-1980s, it made sense that environmentalists saw CAFE as a good *technical tool* for reducing our dependence on oil and cutting carbon emissions. Unfortunately, the best technical solutions don't always make for the best politics. Senators don't vote according to the technical specifications of a proposal. They make decisions based on a variety of factors, especially how the proposal and its opposition are framed. And no amount of public relations can help a badly framed proposal.

Bradsher argues pointedly that "Environmentalists and their Congressional allies have wasted their time since the days of the Bryan bill by repeatedly bringing overly ambitious legislation to the floors of the House and Senate without first striking compromises with the UAW. The sad truth is that by tilting the playing field in favour of SUVs for a quarter of a century, government regulations have left the economy of the Upper Midwest addicted to the production of dangerous substitutes for cars. Any fuel-economy policy must recognize this huge social and economic problem." In light of this string of legislative disasters one might expect environmental leaders to re-evaluate their assumptions and craft a new proposal. Instead, over the last two years, the environmental movement has made only the tactical judgment to bring in new allies, everyone from religious leaders to Hollywood celebrities, to reinforce the notion that CAFE is the only way to free America from foreign oil.

The conventional wisdom today is that the auto industry and the UAW "won" the CAFE fight. This logic implies that industry executives represent what's best for shareholders, that union executives represent what's best for workers, and that environmentalists represent what's best for the environment. All of these assumptions merit questioning. Today the American auto industry is in a state of gradual collapse. Japanese automakers are eating away at American market share with cleaner, more efficient, and outright *better* vehicles.

And American companies are drawing up plans to move their factories overseas. None of the so-called special interests are representing their members' interests especially well.

There is no better example of how environmental categories sabotage environmental politics than CAFE. When it was crafted in 1975, it was done so as a way to save the American auto industry, not to save the environment. That was the right framing then and has been the right framing ever since. Yet the environmental movement, in all of its literal-sclerosis, not only felt the need to brand CAFE as an "environmental" proposal, it failed to find a solution that also worked for industry and labour. By thinking only of their own narrowly defined interests, environmental groups don't concern themselves with the needs of either unions or the industry. As a consequence, we miss major opportunities for alliance building. Consider the fact that the biggest threat to the American auto industry appears to have nothing to do with "the environment." The high cost of health care for its retired employees is a big part of what hurts the competitiveness of American companies. "G.M. covers the health care costs of 1.1 million Americans, or close to half a percent of the total population," wrote the *New York Times'* Danny Hakim recently. "For G.M., which earned $1.2 billion [in profits] last year, annual health spending has risen to $4.8 billion from $3 billion since 1996... Today, with global competition and the United States health care system putting the burden largely on employers, retire medical costs are one reason Toyota's $10.2 billion profit in its most recent fiscal year was more than double the combined profit of the Big Three."

Because Japan has national health care, its auto companies aren't stuck with the bill for its retirees. And yet if you were to propose that environmental groups should have a strategy for lowering the costs of health care for the auto industry, perhaps in exchange for higher mileage standards, you'd likely be laughed out of the room, or scolded by your colleagues because, "Health care is not an environmental issue."

The health care cost disadvantage for US producers is a threat that won't be overcome with tax incentives for capital investments into new factories, or consumer rebates for hybrids. The problem isn't just that tax credits and rebates won't achieve what we need them to achieve, which is save the American auto industry by helping it build better, more efficient cars. The problem is also that these policies, which the environmental community only agreed to after more than two decades of failure, have been thrown into the old CAFE proposal like so many trimmings for a turkey.

Environmentalists — including presidential candidate John Kerry, whose platform includes the new turkey trimmings — as well as industry and labour leaders, have yet to rethink their assumptions about the future of the American auto industry in ways that might reframe their proposal.

Some environmental "realists" argue that the death of the American auto industry– and the loss of hundreds of thousands of high-paying union jobs — isn't necessarily a bad thing for the environment if it means more market share for more efficient Japanese vehicles. Others say saving the American auto industry is central to maintaining the Midwest's middle class. "I don't like to bribe everyone into good behaviour, but it's not bad to help the unions," said Hal Harvey. "We need jobs in this country. Union members are swing voters in a lot of states. And a livable wage is ethically important."

Like Harvey, most environmental leaders are progressives who support the union movement on principle. And though many have met with labour leaders about how to resolve the CAFE quagmire, the environmental movement is not articulating how building a stronger American auto industry and union movement is central to winning action on global warming. Rather, like everything else that's not seen as explicitly "environmental," the future of the union movement is treated as a tactical, not a strategic, consideration.

California's recent decision to require reductions in vehicle greenhouse gas emissions over the next 11 years was widely reported as a victory for environmental efforts against global warming. In fact, coming after over two decades of failure to reverse the gradual decline of fuel efficiency, the decision is a sign of our weakness, not strength. Automakers are rightly confident that they will be able to defeat the California law in court. If they can't, there is a real danger that the industry will persuade Congress to repeal California's special right to regulate pollution under the Clean Air Act. If that happens, California will lose its power to limit vehicle pollution altogether. Today's fleet-wide fuel efficiency average is the same as it was in 1980, according to the Union of Concerned Scientists. This quarter century of failure is not due to one or two tactical errors (though there were plenty of those, as we describe above). Rather, the roots of the environmental community's failure can be found in the way it designates certain problems as environmental and others as not. Automakers and the UAW are, of course, just as responsible as environmentalists for failing to form a strategic alliance. The lose-lose-lose that is the current situation on automobiles is the logical result of defining labour, environmental and industry self-interests so narrowly.

Before his death, David Brower tried to think more creatively about win-win solutions. He spoke often about the need for the environmental community to invest more energy in changing the tax code, a point reporter Keith Bradsher emphasized in *High and Mighty*. "Environmentalists have a history of not taking notice of tax legislation, and paid no attention whatsoever to the depreciation and luxury tax provisions for large light trucks. More egregiously, environmental groups ignored SUVs in the 1990 battle over the Bryan bill, and even disregarded the air-pollution loopholes for light trucks in the 1990 clean air legislation."

Some in the environmental community are trying to learn from the failures of the last 25 years and think differently about the problem. Jason Mark of the Union of Concerned Scientists told us that he has begun the search for more carrots to the Pavley stick. "We need to negotiate from a position of strength. Now is the time for us to propose incentive policies that make sense. We've been working on tax credits for hybrids. Now we need to come up with tax credits for R&D into reduced emissions, and something to ease the industry's pension and health burdens. No one has yet put a big pension deal on the table for them. None of this has yet been explored."

In the end, all sides are responsible for failing to craft a deal that trades greater efficiency for targeted federal tax credits into R&D. One consequence of Japan's public policies that reward R&D with tax credits, suggests Mark, is that Japanese automakers are run by innovation-driven engineers whereas American automakers are run by narrowly focused accountants. For Pavley to inspire a win-win-win deal by industry, environmentalists and the UAW, all three interests will need to start thinking outside of their conceptual boxes.

ENVIRONMENTALISM WITH A SOCIAL CONSCIENCE

The face of the environmental movement is changing. No longer strictly the domain of nature enthusiasts, a new socially conscious environmentalism is becoming mainstream. In Oakland, teenagers from poor neighbourhoods are learning to install solar panels. In the Bronx, gardens are sprouting up on rooftops. Indigenous Americans in Hawaii, New Mexico and Minnesota are collaborating to keep their traditional food supplies free from genetically modified inbreeding. Social justice and environmental movements are creating alliances that broaden the possibility of who will benefit from the greening of America.

Building bridges between social justice activists and nature freaks isn't as hard as it sounds, as demonstrated by the eighteenth annual Bioneers Conference October 19-21 in San Rafael, California. Since 1990, pathbreaking Bioneers—biological pioneers—have provided a forum for activists from around the globe to share visions of combined social and environmental sustainability. Farmers, scientists, educators and others gather to connect their issues and create solutions.

"When you take care of nature, you take care of people. And when you take care of people, you take care of nature," Bioneers founder Kenny Ausubel said. From this vantage point, it makes sense to think about sustainability not only in terms of depleted natural resources like timber or fossil fuel, but also in terms of depleted human resources—such as the disproportionately high number of young black men who are imprisoned in America. It's possible to talk about preserving the oil-rich wilderness of Alaska in the same breath as we talk about preserving the heart and soul of New Orleans.

Van Jones, founder of the Ella Baker Centre for Human Rights in Oakland, calls this "social uplift environmentalism." To counteract what he perceives as twenty years of racial segregation in the environmental movement, Jones said he envisions a world in which "a green wave lifts all boats." His organization's Green for All campaign aims to secure $1 billion in funding for "green-collar" job training across the country. Weatherizing buildings, harvesting solar power and constructing wind farms are jobs that can't be outsourced overseas. Training a green-collar workforce can help lift people out of poverty while improving the ecology of our cities.

Majora Carter is the founder of Sustainable South Bronx (SSBx), an organization working for environmental justice in that low-income neighbourhood. She believes no community should have to bear the brunt of environmental toxicity. Carter lives and works in a place where nearly one in four children has asthma as a result of diesel trucks idling for hours on their way to Manhattan. SSBx is developing the South Bronx Greenway to provide safe public outdoors space and to create better transportation policy. Another project, to remove a 1.25-mile stretch of unused highway running through residential neighbourhoods, will make space for the things residents really need, like parks, housing and businesses. "You shouldn't have to have a lot of green to be green," she says.

The new environmentalism also means recognizing the direct link between cultural diversity and biodiversity, a connection that indigenous activist Winona LaDuke is trying to bring into the public discourse. "Wherever Indigenous peoples still remain, there is also a corresponding enclave of biodiversity," she writes, and that variation of life-forms is vital to the health of any ecosystem. For twenty years she has fought to protect Manoomin, a wild rice that grows on the lakes in Northern Minnesota and is a sacred food to the Anishinaabeg people, from genetic engineering. Changing the DNA of traditional foods upsets the ecological systems in which they grow and impacts the people whose cultures depend on their cultivation. At the Bioneers conference LaDuke said: "I didn't know what seed slavery was until I met up with Monsanto." Keeping agri-giants like Monsanto away from traditional seed supplies and keeping Manoomin wild are two ways indigenous Americans are working to preserve native lands and cultures.

That the environmental movement has gone mainstream is a good thing because it creates the possibility of solving multiple interrelated problems at once. But this opportunity will be missed if the emerging eco-consciousness is co-opted by corporate sellers of hybrid cars and organic cotton Levi's.

Integrating more diverse voices into the environmental justice movement helps ensure that it is truly a people's movement instead of a consumer movement. Bioneers are leading the way with their vision and willingness to forge alliances. After all, if green is the new black, everyone should be invited to the party.

ENVIRONMENTALISM FOR THE 21ST CENTURY

As we begin the 21st century, environmental thinkers are divided along a sharp fault line. There are the doomsayers who predict the collapse of the global ecosystem. There are the technological optimists who believe that we can feed 12 billion people and solve all our problems with science and technology. I do not believe that either of these extremes makes sense. There is a middle road based on science and logic, the combination of which is sometimes referred to as common sense. There are real problems and there is much we can do to improve the state of the environment.

I was born and raised in the tiny fishing and logging village of Winter Harbour on the northwest tip of Vancouver Island, in the rainforest by the Pacific. I didn't realize what a blessed childhood I'd had, playing on the tidal flats by the salmon spawning streams in the rainforest, until I was shipped away to boarding school in Vancouver at age fourteen. I eventually attended the University of BC studying the life sciences: biology, forestry, genetics; but it was when I discovered ecology that I realized that through science I could gain an insight into the mystery of the rainforest I had known as a child. I became a born-again ecologist, and in the late 1960's, was soon transformed into a radical environmental activist.

I found myself in a church basement in Vancouver with a like-minded group of people, planning a protest campaign against US hydrogen bomb testing in Alaska. We proved that a somewhat ragtag looking group of activists could sail a leaky old halibut boat across the North Pacific Ocean and change the course of history. By creating a focal point for opposition to the tests we got on national news and helped build a ground-swell of opposition to nuclear testing in the US and Canada. When that bomb went off in November 1971 it was the last hydrogen bomb ever detonated on planet Earth. Even though there were four more tests planned in the series, President Nixon cancelled them due to public opposition. This was the birth of Greenpeace. Flushed with victory and knowing we could bring about change by getting up and doing something, we were welcomed into the longhouse of the Kwakiutl Nation at Alert Bay near the north end of Vancouver Island. We were made brothers of the tribe because they believed in what we were doing. This began the tradition of the Warriors of the Rainbow, after a Cree legend that predicted one day when the skies are black and the birds fall dead to the ground and the rivers are poisoned, people of all races, colours and creeds will join together to form the Warriors of the Rainbow to save the Earth from environmental destruction. We named our ship the Rainbow Warrior and I spent fifteen years on the front lines of the eco-movement as we evolved from that church basement into the world's largest environmental activist organization.

Next we took on French atmospheric nuclear testing in the South Pacific. They proved a bit more difficult than the US Atomic Energy Administration. But after many years of protest voyages and campaigning, involving loss of life on our side, they were first driven underground and eventually stopped testing altogether.

In 1975 we set sail deep-sea into the North Pacific against the Soviet Union's factory whaling fleets that were slaughtering the last of the sperm whales off California. We put ourselves in front of the harpoons in little rubber boats and made Walter Cronkite's evening news. That really put Greenpeace on the map. In 1979 the International Whaling Commission banned factory whaling in the North Pacific and soon it was banned in all the world's oceans.

In 1978 I was arrested off Newfoundland for sitting on a baby seal, trying to shield it from the Hunter's club. I was convicted; under the draconianly named Seal Protection Regulations that made it illegal to protect seals. In 1984 baby sealskins were banned from European markets, effectively ending the slaughter.

Can you believe that in the early 1980's, the countries of Western Europe were pooling their low and medium level nuclear wastes, putting them in thousands of oil drums, loading them on ships and dumping them in the Atlantic ocean as a way of “disposing” of the wastes. In 1984 a combined effort by Greenpeace and the UK Seafarer’s Union put an end to that practice for good.

By the mid-1980’s Greenpeace had grown from that church basement into an organization with an income of over US$100 million per year, offices in 21 countries and over 100 campaigns around the world, now tackling toxic waste, acid rain, uranium mining and drift net fishing as well as the original issues. We had won over a majority of the public in the industrialized democracies. Presidents and prime ministers were talking about the environment on a daily basis.

For me it was time to make a change. I had been against at least three or four things every day of my life for 15 years; I decided I’d like to be in favour of something for a change. I made the transition from the politics of confrontation to the politics of building consensus. After all, when a majority of people decide they agree with you it is probably time to stop hitting them over the head with a stick and sit down and talk to them about finding solutions to our environmental problems.

All social movements evolve from an earlier period of polarization and confrontation during which a minority struggles to convince society that its cause it is true and just, eventually followed by a time of reconciliation if a majority of the population accepts the values of the new movement. For the environmental movement this transition began to occur in the mid-1980s. The term sustainable development was adopted to describe the challenge of taking the new environmental values we had popularized, and incorporating them into the traditional social and economic values that have always governed public policy and our daily behaviour. We cannot simply switch to basing all our actions on purely environmental values. Every day 6 billion people wake up with real needs for food, energy and materials. The challenge for sustainability is to provide for those needs in ways that reduce negative impact on the environment. But any changes made must also be socially acceptable and technically and economically feasible. It is not always easy to balance environmental, social, and economic priorities. Compromise and co-operation with the involvement of government, industry, academia and the environmental movement is required to achieve sustainability. It is this effort to find consensus among competing interests that has occupied my time for the past 15 years.

Not all my former colleagues saw things that way. They rejected consensus politics and sustainable development in favour of continued confrontation and ever-increasing extremism. They ushered in an era of zero tolerance and left-wing politics. Some of the features of this environmental extremism are:

Environmental extremists are anti-human. Humans are characterized as a cancer on the Earth. To quote eco-extremist Herb Hammond, "of all the components of the ecosystem, humans are the only ones we know to be completely optional". Isn't that a lovely thought?

They are anti-science and technology. All large machines are seen as inherently destructive and unnatural. Science is invoked to justify positions that have nothing to do with science. Unfounded opinion is accepted over demonstrated fact.

Environmental extremists are anti-trade, not just free trade but anti-trade in general. In the name of bioregionalism they would bring in an age of ultra-nationalist xenophobia. The original "Whole Earth" vision of one world family is lost in a hysterical campaign against globalization and free trade.

They are anti-business. All large corporations are depicted as inherently driven by greed and corruption. Profits are definitely not politically correct. The liberal democratic, market-based model is rejected even though no viable alternative is proposed to provide for the material needs of 6 billion people. As expressed by the Native Forest Network, "it is necessary to adopt a global phase out strategy of consumer based industrial capitalism." I think they mean civilization.

And they are just plain anti-civilization. In the final analysis, eco-extremists project a naive vision of returning to the supposedly utopian existence in the garden of Eden, conveniently forgetting that in the old days people lived to an average age of 35, and there were no dentists. In their Brave New World there will be no more chemicals, no more airplanes, and certainly no more polyester suits.

Let me give you some specific examples that highlight the movement's tendency to abandon science and logic and to get the priorities completely mixed up through the use of sensationalism, misinformation and downright lies.

The Brent Spar Oil Rig

In 1995, Shell Oil was granted permission by the British Environment Ministry to dispose of the North Sea oil rig "Brent Spar" in deep water in the North Atlantic Ocean. Greenpeace immediately accused Shell of using the sea as a "dustbin". Greenpeace campaigners maintained that there were hundreds of tonnes of petroleum wastes on board the Brent Spar and that some of these were radioactive. They organized a consumer boycott of Shell and service stations were fire bombed in Germany. The boycott cost the company millions in sales. German Chancellor Helmut Kohl denounced the British government's decision to allow the dumping. Caught completely off guard, Shell ordered the tug that was already towing the rig to its burial site to turn back. They then announced they had abandoned the plan for deep-sea disposal. This embarrassed British Prime Minister, John Major.

Independent investigation revealed that the rig had been properly cleaned and did not contain the toxic and radioactive waste claimed by Greenpeace. Greenpeace wrote to Shell apologizing for the factual error. But they did not change their position on deep-sea disposal despite the fact that on-land disposal would cause far greater environmental impact.

During all the public outrage directed against Shell for daring to sink a large piece of steel and concrete it was never noted that Greenpeace had purposely sunk its own ship off the coast of New Zealand in 1986. When the French government bombed and sunk the Rainbow Warrior in Auckland Harbour in 1985, the vessel was permanently disabled. It was later re-floated, patched up, cleaned and towed to a marine park where it was sunk in shallow water as a dive site. Greenpeace said the ship would be an artificial reef and would support increased marine life.

The Brent Spar and the Rainbow Warrior are in no way fundamentally different from one another. The sinking of the Brent Spar could also be rationalized as providing habitat for marine creatures. It's just that the public relations people at

Shell are not as clever as those at Greenpeace. And in this case Greenpeace got away with using misinformation even though they had to admit their error after the fact. After spending tens of millions of dollars on studies Shell recently announced that it had abandoned any plan for deep-sea disposal and will support a proposal to re-use the rig as pylons in a dock extension project in Norway. Tens of millions of dollars and much precious time wasted over an issue that had nothing to do with the environment and everything to do with misinformation and fundraising hysteria.

To make matters worse, in 1998 Greenpeace successfully campaigned for a ban on all marine disposal of disused oil installations. This will result in hundreds of millions, even billions of dollars in unnecessary costs. One obvious solution would be to designate an area in the North Sea for the creation of a large artificial reef and to sink oil rigs there after cleaning them. This would provide a breeding area for fish and other marine life, enhancing the biological and economic productivity of the sea. But Greenpeace isn't looking for solutions, only conflicts and bad guys.

Exotic Species

There has been a recent flurry of sensationalist warnings about the threat of exotic species. Zealous cadres of conservation biologists descend on wetlands to rip foreign weeds from the bog, declaring that "a rapidly spreading invasion of exotic plants and animals is destroying our nation's biological diversity." It's amazing how a word that was so good, as in "exotic paradise" and "exotic pleasure" is now used to describe an alleged biological Holocaust. I was inspired to write about exotic species when I heard a news story from Washington D.C. in the spring of 1999. The citizens of the Capitol were distressed to find that a family of beavers had taken up residence there and were busy felling the Japanese cherry trees that adorned the banks of the Potomac River. It became a national emergency of sorts and a great effort was made to trap every last beaver; only then were the townspeople put at ease. There was no mention made of the fact that the beaver is a native North American species whereas the cherry trees are exotics, imported from Japan. Yet there was no question which species the public favoured.

In fact, the reason we dislike certain species and like others has nothing to do with whether or not they are exotic. By playing on people's natural suspicion of all things foreign, environmentalists confuse the issue and give the public a misleading picture.

There are actually thousands of exotic species that are not only beneficial, they are the mainstays of our daily lives. Food crops like wheat, rice, and cabbage are all exotics when grown in North America. Vegetables that originated in the Americas such as beans, corn and potatoes are exotics when they are grown in Europe. All around the world, agriculture is largely based on species that originated somewhere else. This is also the case for domestic animals, garden plants and street trees.

There are also hundreds of native species of plants and animals that we consider undesirable. For centuries we have referred to them as weeds, pests, vermin and disease. There are also many exotic species that fall into this category. And, of course, there are many native species that are considered extremely beneficial, especially those that provide food for a growing population.

The point is, both exotic and native species can be desirable or undesirable from a human perspective, depending on how they effect our lives. Our almost innate dislike of rats and spiders has nothing to do with whether or not they are native or exotic, it is due to the possibility of deadly disease or a fatal bite. And even though dandelions in the lawn are hardly a life-and-death issue, millions are spent each year to rid lawns of these "weeds".

Certain exotic species have resulted in severe negative impacts. The most notorious case involved the introduction of European species of animals to Australia, New Zealand, and the Pacific Islands when Europeans colonized these regions beginning about 225 years ago. Many native species, flightless birds and ground-dwelling marsupials in particular, were not able to survive the introduction of predators such as rats, cats and foxes. As a result, hundreds of native species were eliminated. Another well known exotic is Dutch elm disease, a fungus that actually originated in Asia, came through Europe and on to North America where it has resulted in the death of many native elms in the US and Canada. There can be no doubt that we should always be careful when considering the introduction of a new species, and that regulations are needed to prevent undesirable accidental introductions. At the same time we must not lose sight of the fact that introduced species play a vital, indeed essential, role in modern society.

Each species must be evaluated on its own merits. The introduction of some species may be desirable in one region and yet undesirable in others. Islands are particularly susceptible to introductions because they are isolated and their native species are not subjected to as wide a variety of predators and diseases. When rats are introduced to islands that support large bird rookeries there is often a precipitous decline in bird populations due to predation on eggs and nestlings.

There is really no difference when considering the use of an exotic species of tree for managed forests. The main reason we tend to use native species of trees for forestry in North America is because they are the best available in terms of productivity and wood quality. In other regions this is not the case. Radiata pine from California has been very successful in New Zealand, Australia, and Chile. Eucalyptus from Australia is the forestry species of choice in many parts of Brazil, Portugal and South Africa. Douglas-fir from Oregon has become the number two species of softwood produced in France. And Chinese larch is a favourite for reforestation in Scotland where forest cover was lost centuries ago to sheep farming.

The Invisible Poisons

Beginning with the Natural Resources Defence Council's scare tactics about the use of the pesticide Alar on apples, the environmental movement has been very clever at inventing campaigns that make us afraid of our food. They conjure up invisible poisons that will give us cancer, birth defects, mutations, and otherwise kill us in our sleep. We will all soon be reduced to an hermaphroditic frenzy by endocrine mimicking compounds as we approach the Toxic Saturation Point.

Meanwhile, the National Cancer Institute of Canada conducted a joint study with U.S. counterparts beginning in 1994 to investigate the possible relationship between pesticide residues in food and cancer in humans. The findings published in the peer-reviewed journal "Cancer" in 1997, concluded that it could not find "any definitive evidence to suggest that synthetic pesticides contribute significantly to overall cancer mortality", a careful way of saying they found zero connection.

And yet, the article pointed out, over 30 percent of cancers in humans are caused by tobacco, a natural substance. And another 35 percent are caused by poor diet, mainly too much fat and cholesterol and not enough fresh fruit and vegetables. The main effect of the environmental campaign against pesticides is to scare parents into avoiding fresh fruit and vegetables for themselves and their children.

The same kind of scare tactics are now being employed in the campaign against biotechnology and genetically modified foods. Even though there is no evidence of negative human health effects and environmental concerns are blown completely out of proportion, great fear has been whipped up in the public. Large corporations are in retreat and governments are scrambling to get control of the issue.

Unfortunately, some biotechnology companies and associations continue to belittle public concerns and resist disclosure of food ingredients. There is no escaping the fact that this is a new technology and that it must be introduced carefully and sometimes slowly. And public concerns, even when unfounded, must be taken seriously.

To simplify matters, the debate on biotechnology is about whether this science is, in the balance, positive or negative for human health and the environment.

It is unfortunate that the term "biotechnology" has come to be synonymous with "genetic engineering" or "GMO's". Biotechnology is a very broad term used to describe all aspects of new technologies applied to living things. This includes advances in human and veterinary medicine, pest control, crop production and nutrition. Unlike some other aspects of biotechnology, genetic modification is a form of biological rather than chemical intervention. In other words, genetic engineering is an organic science.

It amazes me that in a few short years the molecular biologists that were hailed as crusaders in a new genetic revolution are now reviled and characterised as mad scientists in the grip of greedy corporations bent on destroying the environment. At the WTO conference in Seattle in 1999 we were warned that “entire countries will be held in biological bondage. Genetic engineering will become a biological weapon used for agro-terrorism.” The public is given a fearful impression with images of Frankenstein foods, killer tomatoes, and terminator seeds. Is it any co-incidence that all three of these images are taken directly from scary Hollywood movies? I believe that the campaign of fear now waged against genetic modification is based largely on fantasy and a complete lack of respect for science and logic. In the balance it is clear that the real benefits of genetic modification far outweigh the hypothetical and often contrived risks claimed by its detractors.

Certainly any science or technology can be used for destructive purposes. We already have the ability to annihilate ourselves with physics, in the form of nuclear weapons, with chemistry, in the form of chemical weapons, and with biology, in the form of deadly microbes. I suppose it might be possible to increase the effectiveness of biological weapons with genetic modification, but as far as I am aware there is no need to do so. The ones we have already are more than capable of wiping us out. But the programs of genetic research and development now underway in labs and field stations around the world is entirely about benefiting society and the environment. Its purpose is to improve nutrition, to reduce the use of synthetic chemicals, to increase the productivity of our farmlands and forests, and to improve human health. Those who have adopted a zero-tolerance attitude towards genetic modification threaten to deny these many benefits by playing on fear of the unknown and fear of change.

Many in the anti-biotech movement focus on the issue of corporate control. This is an entirely different subject than the science of genetic modification itself. Corporate control in the form of monopoly can occur in any sector. But, for example, just because Microsoft is alleged to have a monopoly over computer operating systems doesn’t mean we should all throw our computers in the garbage or demand that computers be banned. The technology itself must be analysed and judged separately from the institutional framework that is used to deliver that technology. And, unless we wish to dismantle all the laws relating to intellectual property there will continue to be proprietary rights in new developments, thus requiring an element of control. This is generally accepted as beneficial in that it encourages innovation and competition.

The so-called "precautionary principle" is constantly invoked as an argument for banning genetic modification. Whatever the precautionary principle means, it is not that we should stop learning and applying that knowledge in the real world. We will never know everything and it is impossible to create a world with zero risk. The real question, as so ably put by Indur M. Goklany in "Applying the Precautionary Principle to Genetically Modified Crops", is whether the risks of banning genetic modification are greater or less than the risks of pursuing it. Of course, if we pursue genetic modification, or any other new technology, it must be done with great care and caution. This results in the adoption of a precautionary "approach" or a precautionary "attitude" rather than treating it as a "principle". The daily example of crossing the street is sufficient to explain the difference between the two interpretations. If we would only cross the street when we had a 100% certainty that nothing would go wrong during the crossing we would never leave the curb. But that doesn't mean we should cross without pausing and looking both ways before venturing into the roadway.

Concerns have been raised that GMOs will cause genes to be transferred from our food into our bodies, thus "polluting" our genetic make-up. There is no logical reason why genes from genetically modified organisms should effect our genes any more than those from the trillions of bacteria and the plates full of food that pass through our system every day.

Having commented on these general concerns about GMOs, let me turn to the many benefits that will be available from a responsibly managed program of genetic modification.

From an environmental perspective there are three main areas of positive impact on ecosystems. First, genetically modified crops will generally result in a reduction in the use of chemical pesticides. This will result in a dramatic reduction to the impact on non-target species. For example, when chemical or biological sprays are used to combat pests of the butterfly family (Lepidoptera), all species of butterfly and moth are killed. By contrast, when Bt cotton or Bt corn are grown, only those butterflies or moths that try to feed on the crop are severely impacted. Reducing chemical sprays also results in a cost saving to the farmer.

Second, and perhaps the most important environmental benefit of genetic modification, is the ability to increase the productivity of food crops. Along with other advances in technology, chemicals, and genetics, GMOs will often result in increased yields due to pest resistance, drought resistance, more efficient metabolism, and other genetic traits. It is a fact of arithmetic that the higher the yield of food per unit of land, the less land must be cleared to grow our food. Intensive agricultural production, much of which can be achieved through genetic modification, is a powerful tool to reduce the loss of the world's natural ecosystems. The less land that is required to grow our food, the more that can be retained as forest and wilderness, where biodiversity can flourish. There is no doubt that when natural ecosystems such as forest are converted to agriculture there is a huge loss in biodiversity. Genetic modification could mitigate or even help reverse the continued loss of forest, particularly in the tropical developing countries where this trend is most severe.

Third, the development of herbicide tolerant varieties of food crops allows the adoption of low and zero tillage systems. This results in a considerable reduction in soil erosion, both conserving native soils and reducing the amount of chemical fertiliser inputs.

During a recent visit to Southeast Asia I took part in a seminar on biotechnology in Jakarta, Indonesia. There I met five farmers from South Sulawesi who had just completed a trial of Bt cotton on their farms. They reported that yields had risen from the normal 600 kilos per hectare to an average of 2500 kilos per hectare, a four times increase in yield. At the same time they had reduced pesticide applications from eight sprayings to one spraying, and the single spraying was for a secondary insect pest, not the bollworm that the cotton was now protected against. And yet, environmental NGOs, supported by the Indonesian Minister of the Environment, are trying hard to thwart the efforts of these farmers. Indonesia imports over $1 billion in cotton each year, mainly from Australia. Bt cotton could help Indonesia to be more self-sufficient in cotton production. It could also improve the lot of farmers, reduce chemical use, and result in reduced clearance of natural forestland for agriculture.

There is a tendency to treat medicine and nutrition as separate subjects when in fact food is simply our most important medicine. This is brought home by considering one of the recent advances in genetic modification, the golden rice. Whereas normal rice contains no carotene, by splicing a gene from daffodils into rice plants, it has been possible to produce rice that contains carotene, the precursor of vitamin A. Vitamin A is necessary for eyesight and every year about 500,000 people, mainly children in India and Africa, go blind due to vitamin A deficiency. The golden rice has the potential to eliminate this human tragedy when it is introduced in a few years. At a recent conference on biotechnology in Bangkok, a Greenpeace spokesperson claimed that there was “zero benefit from GMOs”. How can anyone suggest that 500,000 children saved form blindness is a “zero benefit”.

Genetic modification promises to bring a wide range of advances in human health and nutrition. As summarised by Professor Philip Stott of the University of London these include:

Foods with increased digestibility, less saturated fats, cholesterol-reducing properties, and the potential for heart and cancer health benefits.

High-performance cooking oils that will maintain texture at raised temperatures, reduce processing needs, and create healthier products from peanuts, soybeans, and sunflowers.

Edible crops that carry vaccines against diseases such as cholera, hepatitis and malaria.

Crops with reduced allergenicity, e.g. peanuts.

Crops with better storage and transport characteristics through delayed ripening and fungus/pest protection. These include bananas, pineapples, raspberries, strawberries, and tomatoes.

New subsistence crops that will extend agriculture into marginal areas such as saline soils, soils poor in nutrients, and drought-affected regions.

How can a policy of zero-tolerance for genetic modification be justified in the face of these overwhelming benefits? The bankruptcy of the anti-biotech movement position is illustrated by the example of the so-called “Terminator seeds”. When Monsanto proposed to produce a genetically modified soybean variety that produced no viable seeds, environmental groups vilified the company for condemning farmers to dependence on corporate seeds.

Yet, the same environmental groups raise fears that viable seed from genetically modified plants might be harmful to the environment if they spread into the wild. So its damned if you do and damned if you don’t. These groups have made it clear that they are against all genetic modification, and they will invent any argument to support that position, regardless of logical inconsistency or demonstrated fact.

Climate Change

Global climate change is another area where extreme statements are made, in this case on both sides of the debate, when there is little in science to defend them.

Some things are quite certain. Carbon dioxide levels are rising and our consumption of fossil fuels and deforestation in the tropics are probably the main causes. There is a lot of evidence that the earth’s climate is warming: the glaciers in Alaska are retreating and great egrets are visiting northern Lake Huron. But here the consensus ends.

Climate change is a wonderful example to demonstrate the limitations of science. There are two fundamental characteristics of climate change that make it very difficult to use the empirical (scientific) method to predict the future. First there are simply too many uncontrollable variables — the empirical method works best when you can control all the variables except the one you are studying. Second, and even more significant, is the fact that we have only one planet to observe.

If we had 50 planet Earths and increased the carbon dioxide levels on 25 of them, leaving the other 25 alone, we might be able to determine a statistical difference between the two samples. With only one Earth, we are reduced to complex computer models of questionable value, and a lot of guesswork.

Climate change is not about scientific certainty; it is about the evaluation and management of risk. I think it is fair to say that climate change poses a real risk, however small or large. When faced with the risk the logical thing to do is to buy and insurance policy.

Unfortunately we have no actuarial science on which to base the size of the insurance premium; this is where the guesswork comes in. Is it worth reducing fossil fuel consumption by 60 percent to avoid global warming? Should we add the risk of massive nuclear energy construction to offset carbon dioxide emissions? What does "worth doing away" really mean? Is it possible that global warming might have more positive effects than negative ones?

BIODIVERSITY AND FORESTS

The Rainforest Action Network, an eco-political group based in San Francisco, recently published on their Web page that "the International Botanical Society recently released the results of an extensive study showing that, at current rates, two-thirds of the world's plant and animal species will become extinct by the year 2100." The International Botanical Society is nowhere to be found on the Internet.

More seriously, in March 1996, the World Wildlife Fund held a media conference in Geneva during the first meeting of the UN Panel on Forests. They stated that there are now 50,000 species going extinct every year due to human activity, more than at any time since the dinosaurs went extinct 65 million years ago. Most significantly, WWF stated that the main cause of these extinctions is "commercial logging". This was largely due, according to WWF director-general Claude Martin, to "massive deforestation in industrialized countries." The statements made at the media conference were broadcast and printed around the world, giving millions of people the impression that forestry was the main cause of species extinction.

I have tried to determine the basis for this allegation, openly challenging the WWF to provide details of species extinctions caused by logging. To date it would appear that there is no scientific evidence on which to base such a claim. WWF has provided no list of species that have become extinct due to logging. In particular, the claim of "massive deforestation" in industrialized countries runs counter to information provided by the Food and Agriculture Organization of the United Nations. According to the FAO, the area of forest in the industrialized world is actually growing by about 0.2% per year, due to the reforestation of land that was previously cleared for farming.

In May 1996, I wrote to Prince Philip, the Duke of Edinburgh, in his capacity as President of WWF. I stated in part:

"Myself and many colleagues who specialize in forest science are distressed at recent statements made by WWF regarding the environmental impact of forestry. These statements indicate a break with WWF's strong tradition of basing their policies on science and reason. To the best of our knowledge, not a single species has become extinct in North America due to forestry."

Prince Philip replied:

> *"I have to admit I did not see the draft of the statement that (WWF spokesperson) Jean-Paul Jeanrenaud was to make at the meeting of the Intergovernmental Panel on Forestry in Geneva. The first two of his comments (50,000 species per year and the dinosaur comparison) are open to question, but they are not seriously relevant to the issue. However, I quite agree that his third statement (logging being the main cause of extinction) is certainly contentious and the points that you make are all good ones. All I can say is that he was probably thinking of tropical forests when he made the comment."*

Since this exchange of correspondence, WWF has changed the way they characterize the impact of forestry in relation to species extinction. At their "Forests for Life" conference in San Francisco in May 1997, there was no mention made of forestry being the main cause of species extinction. Instead, WWF unveiled a report stating that "three quarters of the continent's forest ecoregions are threatened with extinction, showing for the first time that it is not just individual species but entire ecosystems that are at risk in North America." The word 'extinction' is normally used to mean that something has been completely eliminated. It is entirely beyond reason to suggest that three quarters of the forested areas of North America will become 'extinct' yet this is what WWF is proclaiming to the public.

I have been a subscriber to National Geographic since my father first gave it to me as a gift when I was in school. I have always looked forward to the latest edition, with all the wonders of the world between its covers. Lately, however, even this stalwart of objective science has fallen prey to the prophets of doom who believe a human-caused "mass extinction" is already underway.

The February 1999 special edition on Biodiversity – The Fragile Web, contained a particularly unfortunate article titled "The Sixth Extinction". This refers to the fact that there have been five main extinction events during the past 500 million years, the two most severe of which are believed to have been caused by meteor impacts.

It may well be that all five were of extra-terrestrial origin. During the most recent mass extinction, 65 million years ago, 17 per cent of all the taxonomic families of life were lost, including the dinosaurs. An even greater extinction occurred 250 million years ago when 54 per cent of all families perished, including the trilobites. (family is a term used in taxonomy, two levels up from individual species, for example the cat family, the lily family, and the hummingbird family. Each family contains many, sometimes hundreds, of individual species).

The first two pages of the article contain a photo of Australian scientist, Dr. Tim Flannery, looking over a collection of stuffed and pickled small extinct mammals. The caption under the photo reads: "In the next century half of all species could be annihilated, as were these mammals seen in Tim Flannery's lab at the Australian Museum. Unlike the past five, this mass extinction is being fueled by humans." To be sure, mention is made later in the article that the Australian extinctions were caused by the introduction of cats and foxes when Europeans colonized the region over 200 years ago. This resulted in the loss of about 35 animal species, mainly of flightless birds and ground-dwelling marsupials that were not able to defend themselves against these new predators. This is hardly a “mass extinction” and the cause was a one-time introduction of exotic species.

The rate of extinction of Australian mammals has slowed considerably in recent decades, partly because the most vulnerable species are already extinct, and partly because people started caring about endangered species and began working to prevent them from going extinct. In Australia today there are programs to control wild cats and foxes, some of which have resulted in the recovery of native animal populations.

The use of the Australian example to justify claims that we are experiencing a mass extinction is put into focus by Brian Groombridge, editor of the IUCN Red List of Threatened Species when he states, “around 75% of recorded extinctions... have occurred on islands. Very few extinctions have been recorded in continental tropical forest habitat, where mass extinction events are predicted to be underway.” It is clearly misleading to point to the specific and exceptional case of extinctions caused by the introduction of new species to islands as evidence of a worldwide mass extinction. The National Geographic article goes on to quote biologist Stuart Pimm; “It’s not just species on islands or in rain forests or just birds or big charismatic mammals. It’s everything and it’s everywhere. It is a worldwide epidemic of extinctions.” Yet nearly every example used in the article involves islands such as Australia and Tasmania, Mauritius, Easter Island, and the many islands of the South Pacific.

On pages 48 and 49 of the Sixth Extinction article there is a graph depicting the number of taxonomic families that have existed on earth for the past 600 million years. The graph shows that despite the five great extinctions that have occurred during this period, the number of living families has risen steadily, from around 200 families 500 million years ago to over 1,000 families today. This tendency to diversify over time is one of the major features of evolution. The line of the graph is a thick, solid one until it reaches the present day whereupon it turns abruptly downward as if to indicate a loss of families due to the “mass extinction” now underway. But the line does not remain thick and solid; it turns fuzzy right at the point where it turns down. I wrote to National Geographic and asked, “Why does the line turn fuzzy? Is it because there are actually no known families that have become extinct in recent times? I do not know of any families of 'beetles, amphibians, birds and large mammals' that have become extinct as implied in the text."

The reply to my inquiry came from Robin Adler, one of the researchers who worked on the article. She thanked me for "sharing my thoughts on this complicated and controversial issue" but offered no answer to my question about the graph. Instead she asked me to "Rest assured that... the many members of our editorial team...worked closely with numerous experts in conservation biology, paleobiology, and related fields. The concept of a "sixth extinction" is widely discussed and, for the most part, strongly supported by our consultants and other experts in these areas, although specific details such as the time frame in which it will occur and the number of species that will be affected continues to be debated."

Nowhere in the National Geographic article is there any mention that the "sixth extinction" is a controversial subject; it is presented as if it is a known fact. It is clear from the reply that the "mass extinction" is actually in the future ("the time frame in which it will occur"). In other words there is no evidence that a mass extinction is actually occurring now, even though the article plainly implies that it is. The reply also refers to the sixth extinction as a "concept" implying that it is just an idea rather than a proven fact. Perhaps a better title for the article would have been "No Mass Extinction Yet, Maybe Someday."

It is very frustrating when a trusted institution such as the National Geographic resorts to sensationalism, exaggeration, and misleading illustrations. There is enough bad science and misinformation in the popular press as it is. One can only hope that the present tendency to ignore science and logic, rightly referred to as a "bad intellectual climate" by environmental philosopher Henry H. Webster, will eventually come to an end.

Trees are the Answer

If trees are the answer, you might ask, what is the question? I believe that trees are the answer to a lot of questions about our future. These include: How can we advance to a more sustainable economy based on renewable fuels and materials?

How can we improve literacy and sanitation in developing countries while reversing deforestation and protecting wildlife at the same time? How can we reduce the amount of greenhouse gases emitted to the atmosphere, carbon dioxide in particular? How can we increase the amount of land that will support a greater diversity of species? How can we help prevent soil erosion and provide clean air and water? How can we make this world more beautiful and green? The answer is, by growing more trees and then using more wood, both as a substitute for non-renewable fossil fuels and materials such as steel, concrete and plastic, and as paper products for printing, packaging and sanitation.

When the world's leaders met in Rio de Janeiro in 1992 at the Earth Summit they agreed that three issues are at the top of the international environmental agenda. These are; climate change, biodiversity, and forests. Of course there are many other important issues, including toxic chemicals and nuclear waste, but they are secondary compared to these "Big Three", all of which are global in nature. Unfortunately, most scientists, activists, and policy-makers have specialized in one or the other of these critical areas of concern, and have not focussed as strongly on the profound inter-relationships among them. This has resulted in a situation where most of the environmental movement has adopted a position on forests that is logically inconsistent with its positions on climate change and biodiversity.

The risk of climate change is mainly due to fossil fuel consumption and the emission of CO2. The risk to biodiversity is mainly due to the loss of forests caused by clearing for agriculture and cities. A large part of the solution to both these issues involves growing more trees and using more wood. The environmental movement has adopted a policy that is the opposite of this approach.

By considering forests in isolation from the other major issues, it may seem logical that we can save them by reducing wood consumption, that is, by cutting fewer trees. Greenpeace has appealed to the members of the United Nations to reduce wood consumption and use "environmentally appropriate alternatives" instead. The Rainforest Action Network is campaigning for a 75% reduction in wood use in the United

States through its “wood use reduction program.” The Sierra Club has adopted a formal policy called “zero cut” that would put an end to commercial forestry on federal public land. All these campaigns can be summed up as “cut fewer trees – use less wood.”

There are two problems with this approach. First, just because people stop using wood for fuel or building houses doesn’t mean they will not need warmth or shelter. The fact that 6 billion humans wake up every morning with real needs for energy, food and materials must be taken into account. All the likely substitutes for wood: steel, concrete, plastic and fossil fuels, have far higher emissions of CO_2 associated with their production and use. Using less wood will automatically result in the use of more of these non-renewable resources, and an inevitable increase in CO_2 emissions. Second, much of the land that is used to grow trees could just as well be cleared and used for grazing, farming, and housing. If there is less demand for wood there will be less economic incentive to grow trees and retain forests. It is unrealistic to expect people to retain vast areas of the landscape in forests if they cannot use them. The best way to encourage people to retain and expand forests is to make the resources they provide, including wood, more valuable.

THE ROLE OF GEOGRAPHY IN HAZARD AND GLOBAL CHANGE RESEARCH

At the beginning of this unit, we posed five questions that we will address in this module:

1. Are societies becoming more vulnerable to environmental hazards and disasters? If so, which hazards may intensify in the future as a consequence of global environmental changes?
2. What social/physical factors influence changes in human occupance of hazard zones?
3. How do people respond to environmental hazards and what accounts for differential adjustments (in the short term) and adaptation (in the longer term)?
4. How do societies mitigate the risk of environmental hazards and prepare for future disasters?

5. How do local risks and hazards become the driving forces behind global environmental changes?

A number of factors prohibit simple answers to these questions. First, as we demonstrated above our perceptions and conceptualizations of hazards have changed over time. We no longer think of hazards as singular, purely natural events (as in "acts of God") or as purely technical disasters (brought about by "human fault or failure") but rather as more complex phenomena involving the interaction of natural, social, and technological systems. Thus, hazard typologies based only on the origin of events in the geophysical or the technological realms are no longer tenable; neither is the resulting distinction between purely natural and purely technological hazards. Second, we now think of impacts of, and responses to, hazards as embedded in our social and environmental systems. It is increasingly difficult, if not impossible, to separate the impacts of specific disasters or hazards from broader social and environmental issues. As a consequence, hazard management systems have become more complex and politicized as the range of management alternatives has expanded to include not only geotechnically expedient "solutions" but also options that require decisions made on the basis of social choices (Mitchell 1990; Kates 1985).

These developments in the hazards field have been influenced by and have helped to shape the global environmental change research agenda. For example, research has focused on the difficulty of discerning natural versus human shares in causing global changes, the heavily politicized and ethically loaded debate over how to mitigate the impacts of global change, the role of technology in causing and responding to global change, and the economic challenges and social choices we face in responding to global changes. The hazard research agenda has been extended to include large-scale, regional-to-global, slow-onset, and cumulative hazards in response to the needs of the global change research community. Likewise, the global change community has borrowed impact assessment methodologies, notions of risk and uncertainty, and other concepts and approaches from hazards research to address global problems.

In addressing these complex questions, geography can play a pivotal role. Both the hazards and global change fields have traditionally been interdisciplinary and in the last few years, geographers have become increasingly involved. Geographic scale is crucial to understanding hazards distribution, impact, and reduction (Cutter 1994). The discovery of new hazards and the rediscovery of older ones with more dispersed and cumulative impacts necessitate the globalization of risk and hazard management systems. Unfortunately, because of the enormous difficulties of conducting truly global studies, much hazard research continues to be in the form of local or regional case studies. The articulation between local and global processes will continue to challenge geographers and other researchers.

Geographers also contribute their expertise on the linkages among physical processes and human contexts. This helps us to understand better the causal mechanisms that bring about hazards and disasters, and is of great importance to hazard management. This expertise also helps define the areal extent of the hazard, one of the important characteristics of hazards.

In summary, many linkages exist between hazards and global environmental change research, and geographers have much to contribute. In fact, geographers with expertise in environment-society interactions at different scales, an interest in historical and future trends, and a keen awareness of the ways in which different societies perceive these relations are situated at the intersection of hazards and global change research.

MODIFYING THE HAZARD

Modifying the hazard itself is the most problematic strategy for hazards loss reduction because we ultimately cannot control the physical forces of nature, although many societies have tried (and continue to try). Building dikes and seawalls to hold back the sea as the Dutch have done works for a limited time but in many cases has caused detrimental effects down-drift from the dike or seawall, actually aggravating the processes that such measures were meant to stop (i.e., beach erosion, flooding, and storm surges).

If sea levels rise as a consequence of global warming, these dikes may also not be high enough to hold back the sea in future years. Beach nourishment (i.e., sand replenishment) is often used to maintain beaches along the US east coast, but beach erosion is commonplace and no matter how much sand is placed on the beach, it will eventually be lost. Under current projections of climate change, rising sea levels will accelerate coastal erosion.

Other hazard modification schemes have been attempted with more or (all too often) less success. These include cloud seeding experiments in the 1950s and 1960s to prevent the development of extreme low-pressure systems that cause high winds, severe downpours, and hail; flood abatement and diversion strategies; manipulation of surface and groundwater to induce small-scale seismic events to prevent the build-up of large physical strain, or to reduce frictional resistance within rocks in seismic zones; cooling, barring, or diverting of lava flows; and excavations, mass fillings, and drainage of soils and rocky substrates to prevent mass movements (selected from Smith 1992). Large-scale geo-engineering projects — viewed by some as rather fantastic ideas — have been proposed recently in the context of mitigation strategies for global climate change. These include replenishment of stratospheric ozone by shooting ozone into the stratosphere and the construction of huge space mirrors to reflect solar radiation back into space, thereby reducing solar input to the atmosphere and thus the warming of global temperatures.

For hazards originating in social and technological systems, the obvious strategies to reduce such threats in the first place are conflict resolution, ensuring social equity, improving on the safety of technologies or their usage, or doing without a product that has potentially hazardous effects. Not exclusively, but often with reference to technological hazards management systems, this type of modification is known as prevention. There are a number of ways to accomplish this, such as modifying the technology, preventing initiating events, or preventing outcomes. Modifying the technology could include a ban on the use a particular product. Preventing initiating events normally involves the use of redundant safety systems such as the secondary cooling systems found in most nuclear power plants. Even the best designed systems fail, however, as happened with the nuclear power plant at Three Mile Island, Pennsylvania, in 1979. Preventing outcomes includes a range of technological and design decisions that reduce contaminants at their point of origin such as scrubbers (which reduce the emissions of sulphur dioxide, a key contributing agent in causing acid rain) and other pollution prevention technologies.

As past experience with modifying environmental hazards has shown, the actions taken to prevent or lessen one hazard can actually create new hazards further down the line, in other geographic areas, in different ecological subsystems, or at a later point in time. Replacing certain CFCs with other CFCs and halons is an example. We do not know the environmental impacts of these replacement chemicals, but some have already proven to be even more destructive to the ozone layer than their predecessors. Along these same lines we need to ask what the environmental consequences of large-scale interventions like space mirrors would be. While a number of hazards probably can be modified and lessened without major rethinking of our interactions with nature and technology, other hazards (regardless of their origin or magnitude) may require a new ethic about living with nature and the use of technology. The past holds many lessons to remind us to be more cautious and to consider a long-term systems perspective in attempting to "manage" the environment and ourselves. For hazards originating in the social arena where preventive measures need to address conflicts, equity issues, and the allocation of rights and responsibilities, it seems we may need an even more deeply self-reflexive and cooperative spirit, something — as we all know — that is very hard to realize. *Focus Issue 7* illustrates for one category of hazards how we have to rethink mitigation strategies and the ways in which we interact with the natural environment.

Reducing Human Vulnerability

Reducing human susceptibility to the adverse consequences of hazards/disasters is another way to decrease losses. This is the area where mitigation efforts are best applied. Strategies aimed at reducing vulnerability can be preventative or response-oriented, structural or nonstructural. As a preventative measure, for example, buildings can be made safer (e.g., improving engineering standards to make them more earthquake-resistant; enforcing building codes to heighten wind resistance, and elevating buildings or parts of buildings above flood stages). We can also reduce our vulnerability with non-structural pre-impact options such as emergency planning and preparedness. The development of better forecasting and warning systems drastically reduces the impact of some natural disasters on society (e.g., the losses of lives from hurricanes in the US). Combined forecasting and warning (and if necessary evacuation) systems are successful in lessening the impact of sudden onset, major life-threatening hazards such as floods, hurricanes, and tornados. We now have sophisticated radar-based forecasting systems for hurricanes and tornados that enable emergency managers to advise the public in a timely manner to get out of harm's way and/or take precautions.

Other pre-impact mitigation strategies for vulnerability reduction include land use regulations, planning, risk and hazards laws, and international treaties for hazards reduction and control. In the US, pre-impact mitigation strategies include measures such as zoning ordinances and setbacks in coastal areas or floodplains to prevent people from building in highly vulnerable areas near the water's edge. In the United States, risk and hazards laws are intentionally designed to prevent human exposures and harm (Kirby 1990).

Provisions included in the Clean Air Act, Safe Drinking Water Act, and the Clean Water Act, among others are all considered mitigation strategies for reducing pollution impacts. Also a large number of rules overseen by the Occupational Safety and Health Administration (OSHA) and the Food and Drug Administration (FDA) are designed to ensure the safety of the workplace and the safety of food, food additives, and drugs respectively. Finally, there are quite a few international treaties for hazards reduction and control, ranging from the 1972 London Convention on Biological and Toxic Weapons to the 1989 Basel Convention on the transboundary movement of hazardous wastes to the 1992 Climate Change treaty (Cutter 1993). As many unfortunate examples of evasion of these laws by individual firms or nations indicate (Puckett 1994; Dowie 1996), legislation must be followed by compliance monitoring to ensure their effectiveness.

Response-oriented mitigation strategies to decrease human vulnerability are those that allow people to react more quickly to a disaster such that its impacts can be contained in space, time, and to a minimal number of affected sectors and populations. Regular training for emergency response personnel like fire fighters, state or federal emergency agents, Red Cross volunteers, or the US National Guard fall into this category of measures. Establishing well-coordinated emergency and evacuation plans work toward this end as well. Finally, streamlining and simplifying the bureaucratic procedures to apply for disaster assistance and low-interest loans to rebuild after a disaster have proven to be effective in helping disaster victims get on the track to recovery.

4

Population Geography

INTRODUCTION

Human beings evolved under conditions of high mortality due to famines, accidents, illnesses, infections and war and therefore the relatively high fertility rates were essential for species survival. In spite of the relatively high fertility rates it took all the time from evolution of mankind to the middle of the 19th century for the global population to reach one billion. The twentieth century witnessed an unprecedented rapid improvement in health care technologies and access to health care all over the world; as a result there was a steep fall in the mortality and steep increase in longevity. The population realized these changes and took steps to reduce their fertility but the decline in fertility was not so steep. As a result the global population has undergone a fourfold increase in a hundred years and has reached 6 billion.

DEMOGRAPHIC TRANSITION

Demographers refer to these changes from stable population with high fertility and mortality to a new stability in population due to low fertility and mortality patterns as demographic transition. Demographic transition occurs in four phases; of these the first three phases are characterized by population growth. In the first phase there is a fall in death rate and improvement in longevity; this leads to population growth. In the second phase there is a fall in birth rate but fall is less steep than fall in death rates and consequently there is population growth. In the third phase death rates plateau and replacement level of fertility is attained but the population growth continues because of the large size of population in reproductive age group. The fourth phase is characterized by fall in birth rate to below replacement level and reduction in the proportion of the population in reproductive age group; as a result of these changes population growth ceases and population stabilizes. Experience in some of the developed countries suggest that in some societies even after attainment of stable population there may be a further decline in fertility so that there is a further reduction in the population-so called negative population growth phase of the demographic transition. Different countries in the world have entered the demographic transition at different periods of time; there are also substantial differences in the rate of demographic transition and time taken to achieve population stabilization.

Global Population Scenario

In 1901 the world population was 1.6 billion. By 1960, it became 3 billion, and by 1987, 5 billion and in 1999, 6 billion. Currently, one billion people are added every 12-13 years. During the last decade there has been substantial decline in birth rate. The reasons for decline vary from society to society; urbanization, rising educational attainment, increasing employment among women, lower infant mortality are some major factors responsible for growing desire for smaller families; increasing awareness and improved access to contraception have made it possible for the majority of the couple to achieve the desired family size. In some countries slowing of the population growth has been due to an increase in mortality (e.g. HIV related mortality in sub-saharan Africa). As a result of all these the decline in the global population growth during the nineties is steeper than the earlier predictions. Currently, the annual increment is about 80 million. It is expected to decrease to about 64 million by 2020-25 and to 33 million by 2045-50; 95 % of the growth of population occurs in developing countries. Most demographers believe that the current accelerated decline in population growth will continue for the next few decades and the medium projections of Population Division of United Nations, that the global population will grow to 8.9 billion by 2050 is likely to be achieved.

Changing Age Structure of the Population

During demographic transition along with the growth in number there are changes in the population age structure. While the importance of the population growth as a determinant of quality of life is universally understood, the profoundly serious consequences of changing age structure especially if it occurs too rapidly is not understood by many. Population pyramids graphically represent complex changes in age structure of the population so that it can be readily understood and interpreted. The population pyramids for the global population. Currently nearly half of the global population is below 25 years of age and one sixth are in the age group 15-24. Their choices, efforts and lifestyles will determine not only the population growth but also future improvement in the quality of life in harmony with global ecology. In developed countries the reproductive age group population is relatively small; their fertility is low and the longevity at birth is high.

Population profiles of these countries resemble a cylinder and not a pyramid. These countries have the advantages of having achieved a stable population but have to face the problems of having a relatively small productive workforce to support the large aged population with substantial non-communicable disease burden. Some of the developing countries have undergone a very rapid decline in the birth rates within a short period.

This enabled them to quickly achieve population stabilization but they do face the problems of rapid changes in the age structure and workforce which may be inadequate to meet their manpower requirements. In contrast the population in most of the developing countries (including India) consist of a very large proportion of children and persons in reproductive age. Because of the large reproductive age group (Population momentum) the population will continue to grow even when replacement level of fertility is reached (couples having only two children). It is imperative that these countries should generate enough employment opportunities for this work force and utilise the human resources and accelerate their economic growth. Planners and policy makers in developing countries like India have to take into account the ongoing demographic changes (number and age structure of the population) so that available human resources are optimally utilised as agents of change and development to achieve improvement in quality of life.

DEMOGRAPHIC TRANSITION IN INDIA

Over the last four decades there has been rapid fall in Crude Death Rate (CDR) from 25.1 in 1951 to 9.8 in 1991 and less steep decline in the Crude Birth Rate (CBR) from 40.8 in 1951 to 29.5 in 1991. The annual exponential population growth rate has been over 2% in the period 1961-90. During the nineties the decline in CBR has been steeper than that in the (CDR) and consequently, the annual population growth rate has fallen below 2%. The rate of decline in population growth is likely to be further accelerated during the next decade.

The changes in the population growth rates have been relatively slow, steady and sustained. As a result the country was able to achieve a relatively gradual change in the population numbers and age structure. The short and long term adverse consequences of too rapid decline in birth rates and change in age structure on the social and economic development were avoided and the country was able to adapt to these changes without massive disruptions of developmental efforts.

In spite of the uniform national norms set under the 100% Centrally Funded and Centrally Sponsored Scheme (CSS) of Family Welfare, there are substantial differences in the performance between States as assessed by IMR and CBR. Though the decline in CBR and IMR has occurred in all States, the rate of decline is slower in some States.

At one end of the spectrum is Kerala with mortality and fertility rates nearly similar to those in some of the developed countries. At the other end, there are four large northern States (Uttar Pradesh, Bihar, Madhya Pradesh and Rajasthan) with high Infant Mortality Rate and Fertility Rates. Though the decline in CBR, IMR and CDR has occurred in all States, the rate of decline was slower in some States like U.P. and Bihar. There are substantial differences in CBR and IMR not only between States but also between the districts in the same state. In view of these findings, the NDC Committee on Population recommended that efforts should be made to provide reproductive and child health services at district level and undertake decentralized area-specific micro planning and implementation of appropriate interventions. In response to this recommendation Dept of Family Welfare has abolished the practice of fixing targets for individual contraceptives by the Central Government from April 1996 and had initiated decentralized district based, planning (based on community need assessment), implementation, monitoring and midcourse corrections of FW programme. The experience of states with district based planning, implementation and the impact are being closely monitored.

CONSEQUENCES OF POPULATION GROWTH

Environmental and Ecological Consequences

The already densely populated developing countries contribute to over 95% of the population growth and rapid population growth could lead to environmental deterioration. Developed countries are less densely populated and contribute very little to population growth; however, they cause massive ecological damage by the wasteful, unnecessary and unbalanced consumption the consequences of which could adversely affect both the developed and the developing countries. The review on “Promotion of sustainable development: challenges for environmental policies” in the Economic Survey 1998-99 had covered in detail the major environmental problems, and policy options for improvement; the present review will only briefly touch upon some of the important ecological consequences of demographic transition.

In many developing countries continued population growth has resulted in pressure on land, fragmentation of land holding, collapsing fisheries, shrinking forests, rising temperatures, loss of plant and animal species. Global warming due to increasing use of fossil fuels (mainly by the developed countries) could have serious effects on the populous coastal regions in developing countries, their food production and essential water supplies. The Intergovernmental Panel on Climate Change has projected that, if current greenhouse gas emission trends continue, the mean global surface temperature will rise from 1 to 3.5 degrees Celsius in the next century. The panel’s best estimate scenario projects a sea-level rise of 15 to 95 centimetres by 2100. The ecological impact of rising oceans would include increased flooding, coastal erosion, salination of aquifers and coastal crop land and displacement of millions of people living near the coast. Patterns of precipitation are also likely to change, which combined with increased average temperatures, could substantially alter the relative agricultural productivity of different regions. Greenhouse gas emissions are closely linked to both population growth and development. Slower population growth in developing countries and ecologically sustainable lifestyles in developed countries would make reduction in green house gas emission easier to achieve and provide more time and options for adaptation to climate change. Rapid population growth, developmental activities either to meet the growing population or the growing needs of the population as well as changing lifestyles and consumption patterns pose major challenge to preservation and promotion of ecological balance in India. Some of the major ecological adverse effects reported in India include:

- Severe pressure on the forests due to both the rate of resource use and the nature of use. The per capita forest biomass in the country is only about 6 tons as against the global average of 82 tons.
- Adverse effect on species diversity.
- Conversion of habitat to some other land use such as agriculture, urban development, forestry operation. Some 70-80 % of fresh water marshes and lakes in the Gangetic flood plains has been lost in the last 50 years.
- Tropical deforestation and destruction of mangroves for commercial needs and fuel wood. The country's mangrove areas have reduced from 700,000 ha to 453,000 ha in the last 50 years.
- Intense grazing by domestic livestock.
- Poaching and illegal harvesting of wildlife.
- Increase in agricultural area, high use of chemical fertilizers pesticides and weedicides; water stagnation, soil erosion, soil salinity and low productivity.
- High level of biomass burning causing large-scale indoor pollution.

- Encroachment on habitat for rail and road construction thereby fragmenting the habitat increase in commercial activities such as mining and unsustainable resource extraction.
- Degradation of coastal and other aquatic ecosystems from domestic sewage, pesticides, fertilizers and industrial effluents.
- Over fishing in water bodies and introduction of weeds and exotic species.
- Diversion of water for domestic, industrial and agricultural uses leading to increased river pollution and decrease in self-cleaning properties of rivers.
- Increasing water requirement leading to tapping deeper aquifers which have high content of arsenic or fluoride resulting health problems.
- Disturbance from increased recreational activity and tourism causing pollution of natural ecosystems with wastes left behind by people.

The United Nations Conference on Environment and Development (1992) acknowledged population growth, rising income levels, changing technologies, increasing consumption pattern will all have adverse impact on environment. Ensuring that there is no further deterioration depends on choices made by the population about family size, life styles, environmental protection and equity.

Availability of appropriate technology and commitment towards ensuring sustainable development is increasing throughout the world. Because of these, it might be possible to initiate steps to see that the natural carrying capacity of the environment is not damaged beyond recovery and ecological balance is to a large extent maintained. It is imperative that the environmental sustainability of all developmental projects is taken care of by appropriate inputs at the planning, implementation, monitoring and evaluation stages.

URBANIZATION

The proportion of people in developing countries who live in cities has almost doubled since 1960 (from less than 22 per cent to more than 40 per cent), while in more developed regions the urban share has grown from 61 per cent to 76 per cent. Urbanization is projected to continue well into the next century. By 2030, it is expected that nearly 5 billion (61 per cent) of the world's 8.1 billion people will live in cities. India shares this global trend toward urbanisation.

Globally, the number of cities with 10 million or more inhabitants is increasing rapidly, and most of these new "megacities" are in developing regions. In 1960, only New York and Tokyo had more than 10 million people. By 1999, the number of megacities had grown to 17(13 in developing countries). It is projected that there will be 26 megacities by 2015, (18 in Asia; of these five in India); more than 10 per cent of the world's population will live in these cities (1.7% in 1950). India's urban population has doubled from 109 million to 218 million during the last two decades and is estimated to reach 300 million by 2000 AD. As a consequence cities are facing the problem of expanding urban slums.

Like many other demographic changes, urbanization has both positive and negative effects. Cities and towns have become the engines of social change and rapid economic development. Urbanisation is associated with improved access to education, employment, health care; these result in increase in age at marriage, reduction in family size and improvement in health indices. As people have moved towards and into cities, information has flowed outward. Better communication and transportation now link urban and rural areas both economically and socially creating an urban-rural continuum of communities with improvement in some aspects of lifestyle of both. The ever increasing reach of mass media communicate new ideas, points of reference, and available options are becoming more widely recognized, appreciated and sought. This phenomenon has affected health care, including reproductive health, in many ways. For instance, radio and television programmes that discuss gender equity, family size preference and family planning options are now reaching formerly isolated rural populations. This can create demand for services for mothers and children, higher contraceptive use, and fewer unwanted pregnancies, smaller healthier families and lead to more rapid population stabilisation.

But the rapid growth of urban population also poses some serious challenges. Urban population growth has outpaced the development of basic minimum services; housing, water supply, sewerage and solid waste disposal are far from adequate; increasing waste generation at home, offices and industries, coupled with poor waste disposal facilities result in rapid environmental deterioration. Increasing automobiles add to air pollution. All these have adverse effect on ecology and health. Poverty persists in urban and peri-urban areas; awareness about the glaring inequities in close urban setting may lead to social unrest.

RURAL POPULATION AND THEIR DEVELOPMENT

Over seventy per cent of India's population still lives in rural areas. There are substantial differences between the states in the proportion of rural and urban population (varying from almost 90 per cent in Assam and Bihar to 61 per cent in Maharashtra). Agriculture is the largest and one of the most important sector of the rural economy and contributes both to economic growth and employment. Its contribution to the Gross Domestic Product has declined over the last five decades but agriculture still remains the source of livelihood for over 70 per cent of the country's population. A large proportion of the rural work force is small and consists of marginal farmers and landless agricultural labourers. There is substantial under employment among these people; both wages and productivity are low. These in turn result in poverty; it is estimated that 320 million people are still living below the poverty line in rural India.

Though poverty has declined over the last three decades, the number of rural poor has in fact increased due to the population growth. Poor tend to have larger families which puts enormous burden on their meagre resources, and prevent them from breaking out of the shackles of poverty. In States like Tamil Nadu where replacement level of fertility has been attained, population growth rates are much lower than in many other States; but the population density is high and so there is a pressure on land. In States like Rajasthan, Uttar Pradesh, Bihar and Madhya Pradesh population is growing rapidly, resulting in increasing pressure on land and resulting land fragmentation. Low productivity of small land holders leads to poverty, low energy intake and under nutrition, and this, in turn, prevents the development thus creating a vicious circle. In most of the states non-farm employment in rural areas has not grown very much and cannot absorb the growing labour force. Those who are getting educated specially beyond the primary level, may not wish to do manual agricultural work. They would like better opportunities and more remunerative employment. In this context, it is imperative that programmes for skill development, vocational training and technical education are taken up on a large scale in order to generate productive employment in rural areas. The entire gamut of existing poverty alleviation and employment generation programmes may have to be restructured to meet the newly emerging types of demand for employment.

Rural poor have inadequate access to basic minimum services, because of poor connectivity, lack of awareness, inadequate and poorly functional infrastructure. There are ongoing efforts to improve these, but with the growing aspirations of the younger, educated population these efforts may prove to be inadequate to meet the increasing needs both in terms of type and quality of services. Greater education, awareness and better standard of living among the growing younger age group population would create the required consciousness among them that smaller families are desirable; if all the felt needs for health and family welfare services are fully met, it will be possible to enable them to attain their reproductive goals, achieve substantial decline in the family size and improve quality of life.

Water Supply

In many parts of developed and developing world, water demand substantially exceeds sustainable water supply. It is estimated that currently 430 millions (8% of the global population) are living in countries affected by water stress; by 2020 about one fourth of the global population may be facing chronic and recurring shortage of fresh water. In India, water withdrawal is estimated to be twice the rate of aquifer recharge; as a result water tables are falling by one to three meters every year; tapping deeper aquifers have resulted in larger population groups being exposed to newer health hazards such as high fluoride or arsenic content in drinking water. At the other end of the spectrum, excessive use of water has led to water logging and increasing salinity in some parts of the country. Eventually, both lack of water and water logging could have adverse impact on India's food production. There is very little arable agricultural land which remains unexpected and in many areas, agricultural technology improvement may not be able to ensure further increase in yield per hectare. It is, therefore, imperative that research in biotechnology for improving development of foodgrains strains that would tolerate salinity and those which would require less water gets high priority. Simultaneously, a movement towards making water harvesting, storage and its need based use part of every citizens life should be taken up.

Food Security

Technological innovations in agriculture and increase in area under cultivation have ensured that so far, food production has kept pace with the population growth. Evolution of global and national food security systems have improved access to food. It is estimated that the global population will grow to 9 billion by 2050 and the food production will double; improvement in purchasing power and changing dietary habits (shift to animal products) may further add to the requirement of food grains. Thus, in the next five decades, the food and nutrition security could become critical in many parts of the world especially in the developing countries and pockets of poverty in the developed countries.

In India one of the major achievements in the last fifty years has been the green revolution and self-sufficiency in food production. Food grain production has increased from 50.82 in 1950-51 to 200.88 million tons in 1998-99 (Prov.). It is a matter of concern that while the cereal production has been growing steadily at a rate higher than the population growth rates, the coarse grain and pulse production has not shown a similar increase. Consequently there has been a reduction in the per capita availability of pulses (from 60.7 grams in 1951 to 34 grams per day in 1996) and coarse grains. Over the last five decades there has been a decline in the per capita availability of pulses. During the last few years the country has imported pulses to meet the requirement. There has been a sharp and sustained increase in cost of pulses, so there is substantial decline in per capita pulses consumption among poorer segment of population. This in turn could have an adverse impact on their protein intake. The pulse component of the “Pulses and Oil Seeds Mission” need to receive a major thrust in terms of R&D and other inputs, so that essential pulse requirement of growing population is fully met.

Rising cost of pulses had a beneficial effect also. Till eighties in central India wages of landless labourers were given in the form Kesari Dal which was cheaper than cereals or coarse grains. Consumption of staple diet of Kesari Dal led to crippling disease of neuro lathyrism. Over the last three decades the rising cost of pulses has made Kesari Dal more expensive than wheat or rice and hence it is no longer given to labourers as wages for work done; as a result the disease has virtually disappeared from Central India. Over years the coarse grain production has remained stagnant and per capita availability of coarse grain has under gone substantial reduction; there has been a shift away from coarse grains to rice and wheat consumption even among poorer segment of population. One of the benefits of this change is virtual elimination of pellagra which was widely prevalent among low income group population in Deccan Plateau whose staple food was sorghum.

Coarse grains are less expensive than rice and wheat; they can thus provide higher calories for the same cost as compared to rice and wheat. Coarse grains which are locally produced and procured if made available through TPDS at subsidised rate, may not only substantially bring down the subsidy cost without any reduction in calories provided but also improve “targetting”-as only the most needy are likely to access these coarse grains. Another area of concern is the lack of sufficient focus and thrust in horticulture; because of this, availability of vegetables especially green leafy vegetables and yellow/red vegetables throughout the year at affordable cost both in urban and rural areas has remained an unfulfilled dream. Health and nutrition education emphasizing the importance of consuming these inexpensive rich sources of micronutrients will not result in any change in food habits unless there is harnessing and effective management of horticultural resources in the country to meet the growing needs of the people at affordable cost. States like Tamil Nadu and Himachal Pradesh have initiated some efforts in this direction; similar efforts need be taken up in other states also.

POPULATION PROJECTIONS FOR INDIA AND THEIR IMPLICATIONS

Right from 1958 the Planning Commission has been constituting an Expert Group on Population Projections prior to the preparation of each of the Five Year Plans so that the information on the population status at the time of initiation of the Plan and population projections for future are available during the preparation of the Plan. Population projections have been utilised not only for planning to ensure provision of essentials necessities such as food, shelter and clothing but also prerequisites for human development such as education, employment and health care. Over the years there has been considerable refinement in the methodology used for population projections and substantial improvement in the accuracy of predictions. The projections made by the Standing Committee on Population Projection in 1988 for the year 1991 was 843.6 million; this figure was within 0.3% of the 846.3 million reported in the Census 1991. In 1996, Technical Group on Population Projections, had work out the population projections for the country and the states for the period 1996 to 2016 on the basis of census 1991 and other available demographic data.

Economic Implications

Population growth and its relation to economic growth has been a matter of debate for over a century. The early Malthusian view was that population growth is likely to impede economic growth because it will put pressure on the available resources, result in reduction in per capita income and resources; this, in turn, will result in deterioration in quality of life. Contrary to the Malthusian predictions, several of the East Asian countries have been able to achieve economic prosperity and improvement in quality of life inspite of population growth. This has been attributed to the increase in productivity due to development and utilisation of innovative technologies by the young educated population who formed the majority of the growing population. These countries have been able to exploit the dynamics of demographic transition to achieve economic growth by using the human resources as the engine driving the economic development; improved employment with adequate emoluments has promoted saving and investment which in turn stimulated economic growth.

However, not all countries, which have undergone demographic transition, have been able to transform their economies. Sri Lanka in South Asia underwent demographic transition at the same time as South East Asian countries but has not achieved the economic transition. It is now realized that population growth or demographic transition can have favourable impact on economic growth only when there are optimal interventions aimed at human resource development (HRD) and appropriate utilisation of available human resources. For India the current phase of demographic transition with low dependency ratio and high working age group population, represents both a challenge and an opportunity.

The challenge is to develop these human resources through appropriate education and skill development and utilise them fully by giving them appropriate jobs with adequate emoluments; if this challenge is met through well planned schemes for HRD and employment generation which are implemented effectively, there will be improved national productivity and personal savings rates; appropriate investment of these savings will help the country to achieve the economic transition from low economic growth-low per capita income to high economic growth-high per capita income.

It is imperative to make the best use of this opportunity so as to enable the country and its citizens to vault to the high income-high economic growth status and stabilize at that level.

Interstate Differences

There are marked differences between States in size of the population and population growth rates, the time by which replacement level of fertility is to be achieved and age structure of the population. If the present trend continues, most of the Southern and the Western States are likely to achieve TFR of 2.1 by 2010. Urgent energetic steps to assess and fully meet the unmet needs for maternal and child health (MCH) care and contraception through improvement in availability and access to family welfare services are needed in the States of UP, MP, Rajasthan and Bihar in order to achieve a faster decline in their mortality and fertility rates. The five states of Bihar, Uttar Pradesh, Madhya Pradesh, Rajasthan and Orissa, which constitute 44% of the total population of India in 1996, will constitute 48% of the total population of India in 2016. These states will contribute 55% of the total increase in population of the country during the period 1996-2016. In all the states performance in the social and economic sector has been poor. The poor performance is the outcome of poverty, illiteracy and poor development which coexist and reinforce each other. The quality and coverage under health services is poor and the unmet need for FW services is about 30%. Urgent energetic steps are required to be initiated to assess and fully meet the unmet needs for maternal and child health (MCH) care and contraception through improvement in availability and access to family welfare services in the states of UP, MP, Rajasthan and Bihar in order to achieve a faster decline in their mortality and fertility rates. The performance of these states would determine the year and size of the population at which the country achieves population stabilisation.

There are also marked differences between States in socio-economic development. Increasing investments and rapid economic development are likely to occur in the States where literacy rates are high; there is ready availability of skilled work force and adequate infrastructure. In these States, population growth rates are low. If equitable distribution of the income and benefits generated by development is ensured, substantial increase in per capita income and improvement in quality of life could occur in these States in a relatively short time. In majority of States with high population growth rates, the performance in the social and economic sector has been poor. The poor performance could be the outcome of a variety of factors including paucity of natural, financial or human resources. Poverty, illiteracy and poor development coexist and aggravate each other. In order to promote equity and reduce disparity between States, special assistance has been provided to the poorly performing States. The benefits accrued from such assistance has to a large extent depended upon:

- the States' ability to utilise the available funds; improve quality & coverage of services and facilities, increase efficiency and improve performance.

- community awareness and ability to utilise the available services.

In spite of the additional assistance provided, improvement in infrastructure, agriculture and industry have been sub-optimal and the per capita income continues to be low in most of the poorly performing States. These States also have high birth rates and relatively low literacy rates. It is imperative that special efforts are made during the next two decades to break this vicious self perpetuating cycle of poor performance, poor per capita income, poverty, low literacy and high birth rate so that the further widening of disparities between States in terms of per capita income and quality of life is prevented.

The higher population growth rates and low per capita income in poorly performing States are likely to have a major impact on several social sector programmes. The health status of the population in these States is poor; the health sector programme will require inputs not only for improving infrastructure and manpower, but also increasing efficiency and improving performance. The Family Welfare Programme has to address the massive task of meeting all the unmet needs for MCH and contraception so that there is a rapid decline in mortality and fertility rates. Due to high birth rate, the number of children requiring schooling will be large. The emphasis in the education sector on primary education is essential to ensure that the resource constraints do not result in an increase in either proportion or number of illiterates. Emphasis on prevocational and vocational training in schools will enable these children to acquire skills through which they will find gainful employment later.

Migration

The available data from census shows that until 1991 both internal and international migration has been negligible. The Technical Group while computing the population projection upto 2016, has assumed that the component of migration between major States and from India will be negligible. This assumption may not be valid if there is further widening of the disparity between States in terms of economic growth and employment opportunity. Given the combination of high population growth, low literacy and lack of employment opportunities in the poorly performing States, there may be increasing rural to urban migration as well as interstate migration especially of unskilled workers. Such migration may in the short run assist the migrants in overcoming economic problems associated with unemployment. However, the migrant workers and their families may face problems in securing shelter, education and health care. It is essential to build up a mechanism for monitoring these changes. Steps will have to be taken to provide for the minimum essential needs of the vulnerable migrant population.

Labour, Employment and Manpower

Population, which is engaged in any economic activity (employed persons) and population seeking work (unemployed) constitute Labour Force. India has the second largest labour force in the world. Projection of labour force is pre-requisite ensuring optimal utilisation of available human resources. Manpower development is then taken up to provide adequate labour force, of appropriate skills and quality to different sectors so that there is rapid socioeconomic development and there is no mismatch between skills required and skills available. Planning also attempts to provide enabling environment for employment generation (both self employment and wage employment) in public, private and voluntary sectors in urban and rural areas.

Labour force in India will be increasing by more than 10 million per annum during 1997-2012. It will be imperative to plan for and achieve adequate agricultural and industrial growth to absorb this work force. Most of the persons entering the labour force will be educated and have some skills. Increasing literacy and decreasing birth rates may result in more women seeking economically productive work outside home. It will be important to generate appropriate and renumerative employment at places where labour force are available so as to reduce interstate and urban migration in search of employment. Attempts should be made to eliminate bonded labour, employment of children and women in hazardous industries and minimising occupational health hazards.

Planners face the challenge to have sustained high economic growth rate in sectors that are labour-intensive to ensure adequate employment generation for productively utilising this massive work force. If the massive work force of literate, skilled, aware men and women in age-group 20-60 years get fully employed and adequately paid they could trigger off a period of rapid economic development. As they have very few dependant children and elders there will be increased savings and investments at household level; this in turn will improve the availability of resources for accelerating economic growth. The current stage of demographic transition thus provides the country with the opportunity window for using human resources as the engine to power economic development and improving the quality of life of all the citizens.

SEX RATIO

The reported decline in the sex ratio during the current century has been a cause for concern. The factors responsible for this continued decline are as yet not clearly identified. However, it is well recognised that the adverse sex ratio is a reflection of the gender disparity. Higher childhood mortality in girl children is yet another facet of the existing gender disparities and consequent adverse effect on survival. In the reproductive age group the mortality rates among women are higher than those among men. The continued high maternal mortality is one of the major factors responsible for this. Effective implementation of the Reproductive and Child Health Programme is expected to result in a substantial reduction in maternal mortality. At the moment, the longevity at birth among women is only marginally higher than that among men. However over the next decade life expectancy among women will progressively increase. Once the reproductive age group is crossed, the mortality rates among women are lower as women outlive and outnumber men in the age group 65 and above The needs especially of the widowed women have to be met so that quality of life does not deteriorate. The census 2001 will collect and report vital data on sex disaggregated basis; this will be of help in identifying and taking up appropriate interventions in correcting gender disparity; continued collection, collation, analysis and reporting of sex disaggregated data from all social sectors will also provide a mechanism to monitor whether girls and women have equal access to services.

There are substantial differences in sex ratio at birth and in different age groups between states. The observed sex ratio of 110 is higher than the internationally accepted sex ratio at birth of 106. There are substantial differences among states in the reported sex ratio at birth. There had been speculations whether female infanticide, sex determination and selective female foeticide are at least in part responsible for this. The Government of India has enacted a legislation banning the prenatal sex determination and selective abortion. Intensive community education efforts are under way to combat these practices, especially in pockets from where female infanticide and foeticide have been reported.

Increasing Longevity

Over the coming decades the country will be facing a progressive increase both in the proportion and number of persons beyond 60 years of age. Over the next 20 years the population of more than 60 years will grow form 62.3 million to 112.9 million; the subsequent decades will witness massive increase in this age group. Increasing longevity will inevitably bring in its wake increase in the prevalence of non-communicable diseases. The growing number of senior citizens in the country poses a major challenge and the cost of providing socio-economic security and health care to this population has to be met. Currently several region and culture specific innovative interventions to provide needed care to this population are underway; among these are efforts to reverse the trend of break up of joint families. If these efforts succeed, it will be possible to provide necessary care for rapidly increasing population of senior citizens in the subsequent two decades within the resources of the family and the country.

Majority of the people in their sixties will be physically and psychologically fit and would like to participate both in economic and social activities. They should be encouraged and supported to lead a productive life and contribute to the national development. Senior citizens in their seventies and beyond and those with health problems would require assistance.

So far, the families have borne major share in caring for the elderly. This will remain the ideal method; however, there are growing number of elderly without family support; for them, alternate modes for caring may have to be evolved and implemented. Improved health care has “added years to life”. The social sectors have to make the necessary provisions for improving the quality of life of these senior citizens so that they truly “ add life to years.”

Census and Trends of Population

Census is an official counting of a population:' In India it started in 1881. Since then it has been continued at an interval of 10 years. At the beginning of this century in 1901, the population of the undivided India was 242 millions. After independence the first census was held in 1951 and the population was 361 millions. The population growth marked a steady increase in the subsequent censuses. It rose to 439 millions in 1961, 548 millions in 1971, 548 millions in 1971, 685 millions in 1981 and 844 millions 1991. The last census was held in 2001 and it recorded a population of 1027 millions. This population explosion poses a serious *socio-economic* problem in the country.

Causes of the population explosion: The main causes of the increase of population are: (i) *better health conditions resulting from effective control of epidemics, (ii) natural increases due to high birth rates, (iii) efficient handling of famine situations and (iv) general improvement in the economic development due to scientific inventions.*

Density of Population in India

Distribution of population refers to general distribution of population of a region or a country. But density of population refers to average number of persons per sq km. The table given on the next page shows the distribution of population and density of population in the states and *Union Territories of India* according to the census of 2001. The table shows that the highest population is found in the state of *Uttar Pradesh (16,6052,859)* and the highest density is recorded in the state of *West Bengal (904*). The lowest population is found in the state of *Sikkim* and the lowest of population is recorded in the state of *Arunachal Pradesh*. According the *Union Territories*, the highest population and highest density of population occur in *Delhi.* The lowest population is found in *Lakshadweep*; but the lowest density of population prevails in the *Andaman and*

Nicobar Islands. The over-all picture (*States and the Union territories together*) shows the following facts: (1) the highest population in *U.P.*, (2) the highest density of population in *Delhi*, (3) the lowest population in *Lakshadweep* and (4) the lowest density of population in *Arunachal Pradesh*.

The Distribution of Population

Division According to Density of Population: The distribution of population in India shows the following density pattern according to census 2001.

Regions of Shows population Density (density below 100 per sq. km.): In includes *Jammu and Kashmir, Sikkim, Arunachal Pradesh, Mizoram states and Union Territories Andaman and Nicobar*. In the low population density due to ragged is topography and forested land with the severity of climate.

Regions of Medium Population Density (between 101 and 250 per sq. km.): It includes *Himachal Pradesh, Madhya Pradesh, Manipur, Meghalaya, Nagaland, Orissa, Rajasthan, Chhattisgarh and Uttaranchal states.* These regions are hilly, mountainous or forested, and some are deserted. Hence population is medium.

Regions of Considerably High Population Density (between 251 and 500 per sq. km.): This region includes *Andhra Pradesh, Assam, Gujrat, Haryana, Karnataka, Maharashtra, Punjab, Tamil Nadu, Tripura, Goa, Jharkhand states and Union Territories of Darda & Nagar Haveli.* Fairly high population of this region is due to the advancement of agriculture, mining and industry. Economic progress and job opportunities contribute much for this population.

Regions of High Population Density (between 501 and 1000 per sq. km.): *Bihar, Kerala, Uttar Pradesh and West Bengal* are included in this population zone. This high population is due to very fertile soil, advancemant of agriculture, minings, industries, trade and commerce and opportunities for subsistence.

Regions of Very High Population Density (above 1001 per sq. km.): It includes the *Union Terrtories of Delhi, Chandigarh, Pandicherry, Lakshadweep and Daman & Diu.* The high density of this region is due to high economic and administrative activites.

The Causes for the Uneven Distribution of Population

The distribution of population in India is not uniform. Some areas have high density of population, while others have medium or low density. The following physical and cultural factors are responsible for the uneven distribution of population in the country. The physical factors are gifts of nature; they influence much for the distribution of population.

Difference in Relief: The relief of the country exerts immense influence in the population distribution of a country. Extremely ragged topography associated with thick forest-cover do not encourage settlement as in the Himalayas and in the north-eastern hilly states of India. But the river valleys with alluvial plaints provide easy livings for which the population is high. The population of the Ganga-brahmaputra plain is distinctively high.

Variation in Vlimate: Climate exerts a great influence on human settlement. The *Marausthali of western Rajasthan* is sparsely populated; it is the hottest place in India and it has the extreme type of climate with little rainfall. Due to the adverse climate condition, the *Marusthali* is sparsely populated. On the other hand, the mild and equitable climate of the *Ganga plain* encourages settlements.

Influence of Soil: Agriculture depends on soil condition. The fertility of soil determines the cultivation of crops. Thus the livings and subsistence of the people depend on soil and low on rocky waste or infertile soil. The great northern plains of India have fertile soil and on these plains density of population is remarkably high.

Influence of River: Rivers provide water to agriculture and other indispensable needs (drinking water and others) of the people. They also provide avenues for trade and commerce. That is why it is frequently said; the river valleys are the cradles of civilization. All the river valleys, which have fertile soil and tolerable climate, are thickly populated.

Presence of Minerals: Mineral deposits attract population. The discovery of enormous mineral deposits in the

Chhotanagpur plateau region has contributed much to the growth of high concentration of population to this region. The cultural factors are also responsible for the uneven distribution of population. These factors are man-made and popularly known as non-physical factors or cultural factors.

Development of Industries: Development of industries also attracts population. A few decades ago, there was very low population in Durgapur region; but with the development of industries in the Durgapur belt, the population has steadily increased.

Historical & Political Factors: After the partition of Bengal, when the Indian indepence was achieved, the population of *West Bengal* grew up rapidly due to the influx of the people from the other side of *Bengal*. Religious Influence: *Varanasi, Mathura, Haridwar, Nabadweep, Puri* are the sacred religious centres of the *Hindus, Agra* of the *Muslims and Amritsar of the Sikhs.* They are densely populated due to religious factors.

5

Economic Geography

Economic geography is the study of the location, distribution and spatial organization of economic activities across the Earth. The subject matter investigated is strongly influenced by the researcher's methodological approach. Neoclassical location theorists, following in the tradition of Alfred Weber, tend to focus on industrial location and use quantitative methods. Since the 1970s, two broad reactions against neoclassical approaches have significantly changed the discipline: Marxist political economy, growing out of the work of David Harvey; and the new economic geography which takes into account social, cultural, and institutional factors in the spatial economy.

Economic geography is usually regarded as a subfield of the discipline of geography, although recently economists such as Paul Krugman and Jeffrey Sachs have pursued interests that can be considered part of economic geography.

Krugman has gone so far as to call his application of spatial thinking to international trade theory the "new economic geography", which directly competes with an approach within the discipline of geography that is also called "new economic geography". The name geographical economics has been suggested as an alternative.

Given the variety of approaches, economic geography has taken to many different subject matters, including: the location of industries, economies of agglomeration (also known as "linkages"), transportation, international trade and development, real estate, gentrification, ethnic economies, gendered economies, core-periphery theory, the economics of urban form, the relationship between the environment and the economy (tying into a long history of geographers studying culture-environment interaction), and globalization.

This list is by no means exhaustive.

Areas of Study

- *Theoretical economic Geography* focuses on building theories about spatial arrangement and distribution of economic activities.
- *Regional economic geography* examines the economic conditions of particular regions or countries of the world. It deals with economic regionalisation as well.
- *Critical economic geography* is approach from the point of view of contemporary critical geography and its philosophy.
- *Behavioural economic geography* examines the cognitive processes underlying spatial reasoning, locational decision making, and behavior of firms and individuals.

Branches

Thematically economic geography can be divided into these sub disciplines:

- 'Geography of Agriculture.
- 'Geography of Industry.
- 'Geography of International Trade.
- 'Geography of Resources.
- 'Geography of Transport and Communication.

However, their areas of study may overlap with another geographical sciences or may be considered on their own.

HISTORY OF ECONOMIC GEOGRAPHY

In the history of economic geography there were many influences coming mainly from economics and geographical sciences.

First traces of the study of spatial aspects of economic activities on Earth can be found in Strabo's *Geographika* written almost 2000 years ago. This has recently been challenged, however, by seven Chinese maps of the State of Qin dating to the 4th century BC. During the period known in geography as environmental determinism notable (though later much criticized) influence came from Ellsworth Huntington and his theory of climatic determinism.

Valuable contributions came from location theorists such as Johann Heinrich von Thunen or Alfred Weber. Other influential theories were Walter Christaller's Central place theory, the theory of core and periphery.

Fred K. Schaefer's article *Exceptionalism in geography: A Methodological Examination* published in American journal Annals (Association of American Geographers) and his critique of regionalism had a big impact on economic geography. The article became a rallying point for the younger generation of economic geographers who were intent on reinventing the discipline as a science. Quantitative methods became prevailing in research. Well-known economic geographers of this period are William Garrison, Brian Berry, Waldo Tobler, Peter Haggett, William Bunge (Apurba Dutta, Ranibandh) Contemporary economic geographers tend to specialize in areas such as location theory and spatial analysis (with the help of geographic information systems), market research, geography of transportation, land or real estate price evaluation, regional and global development, planning, Internet geography, innovation, social networks and others.

Economists and Economic Geographers

Economists and economic geographers differ in their methods in approaching similar economic problems in several ways. To generalize, an economic geographer will take a more holistic approach in the analysis of economic phenomena, which is to conceptualize a problem in terms of space, place and scale as well as the overt economic problem that is being examined. The economist approach, according to economic geographers, has four main drawbacks or manifestations of "economic orthodoxy that tends to homogenize the economic world in way that economic geographers try to avoid.

LOCATION THEORY

Location theory is concerned with the geographic location of economic activity; it has become an integral part of economic geography, regional science, and spatial economics. Location theory addresses the questions of what economic activities are located where and why. Location theory rests — like Micro-economic theory generally — on the assumption that agents act in their own self interest. Thus firms choose locations that maximize their profits and individuals choose locations that maximize their utility.

Origins

While others should get some credit for even earlier work (e.g., Richard Cantillon, Etienne Bonnot de Condillac, David Hume, Sir James D. Steuart, and David Ricardo), it was not until Johann Heinrich von Thunen's first volume of *Der Isolierte Staat* in 1826 that location theory can be said to have really gotten underway. Indeed, the prominent regional scientist Walter Isard has called von Thunen "the father of location theorists." In *Der Isolierte Staat*, von Thunen notes that the costs of transporting goods consumes some of Ricardo's economic rent. He notes that because these transportation costs and, of course, economic rents, vary across goods, different land uses and use intensities will result with distance from the marketplace.

A German hegemony of sorts seems to have taken hold in location theory from the time of von Thunen through to Walter Christaller's 1933 book *Die Zentralen Orte in Suddeutschland*, which formulated much of what is now understood as central place theory. An especially notable contribution was one by Alfred Weber, who published *Uber den Standort der Industrien* in 1909. Working from a model akin to a physical frame adapted from some ideas by Pierre Varignon (a Varignon frame), Weber applies freight rates of resources and the finished goods along with the finished good's production function to develop an algorithm that identifies the optimal location for manufacturing plant. He also introduces distortions induced by labour and both agglomerative and deglomerative forces. Weber then moves on to discuss groupings of production units, anticipating Losch's market areas.

Carl Wilhelm Friedrich Launhardt conceived much of that for which Alfred Weber received credit, prior to Weber's work. Moreover, his contributions are surprisingly more modern in their analytical content than Weber's. This suggests that

Launhardt was ahead of his time and simply was not readily understood by many of his contemporaries. Whether Weber was familiar with Launhardt's publications remains unclear. Weber was most certainly influenced by others, most notably Wilhelm Roscher and Albert Schaffle, who seem likely to have read Launhardt's work. Regardless, location theoretic thought blossomed only after Weber's book was published.

Resources and Development

Humans through technology and institutions transform things available with nature.

- Resources are of two types natural and human.
- Resources can be classified in the following ways –
  - (a) On the basis of origin – biotic and abiotic.
  - (b) On the basis of exhaustibility – renewable and non-renewable.
  - (c) On the basis of ownership – individual, community, national and international.
  - (d) On the basis of status of development – potential, developed stock and reserves.
- The oceanic area up to 12 nautical miles from the coast line is called *territorial waters* of a country.
- The area up to 200 km from the coast line in which the country has the exclusive rights to exploit the natural resources is the *exclusive economic zone*. It includes territorial waters in it.
- Resource planning is the technique or strategy for the judicious use of resources in a country.
- *Sustainable economic development* means 'development should take place without damaging the environment, and development in the present should not compromise with the needs of the future generations.'
- *Agenda 21* is the declaration signed in 1992 at the UNCED, Rio de Janeiro, Brazil. It aims at achieving global sustainable development. It is an agenda to combat environmental damage, poverty, disease through global co-operation.
- Land supports natural vegetation, wild life, human life,

economic activities, transport, and communication systems.

- About 43 per cent of the land area is plain, which provides facilities for agriculture and industry.
- Mountains account for 30 per cent of the total surface area of the country. They ensure perennial flow of some rivers; provide facilities for tourism and ecological aspects.
- About 27 per cent of the area of the country is the plateau region. It possesses rich reserves of minerals, fossil fuels and forests.
- Islands are less than 1 per cent of the area of the country. They provide opportunities for sea trade, tourism, and fish catch.
- Net sown area is over 80 per cent of the total area in Punjab and Haryana. Due to gentle sloping lands covered with fertile alluvial soils and black soils, climate favours cereal cultivation, good irrigation facilities, high population pressure.
- Net sown area is less than 10 per cent in Arunachal Pradesh, Mizoram, Manipur and Andaman Nicobar Islands because of mountainous areas, lack of irrigational facilities, infertile soils, low density of population, etc.
- The use of land is determined both by physical factors such as topography, climate, and soil types as well as human factors such as population density, technological capability and culture and traditions etc.
- If a land is left uncultivated for more than 5 agricultural years it is called Culturable waste land.
- If a land is left uncultivated for the past 1 to 5 agricultural years it is called Other than current fallow.
- If a land is left without cultivation for one or less than one agricultural year it is called Current fallow.
- Net sown area is the total area sown with crops and orchards. Area sown more than once in the same year is counted only once.
- Area sown more than once in an agricultural year plus net sown area is known as gross cropped area.

- Barren Land: This includes all land covered by mountains, deserts, etc.
- Land which cannot be brought under cultivation except at an huge cost is classified as unculturable land.
- The top most layer of the earth crust which is composed of organic and non-organic matter is called soil. Soil is renewable natural resource. The soil is a living system.
- 33 % of geographical area should be under Forest in the country according to the National Forest Policy 1952.
- Alluvial soils are the most widely spread and important soil of our country.
- Alluvial soils are found in the entire northern plains, Rajasthan and Gujarat, eastern coastal plains, deltas of the Mahanadi, Godavari, Krishna and Kaveri rivers.
- Duars, Chos and Terai are the Piedmont plains where alluvial soils are coarse.
- According to their age alluvial soils are of two types: old alluvial (Bangar) and new alluvial (Khadar).
- Black soils are also known as *regur* soils or cotton soils.
- Black soils develops on Basaltic lava rocks.
- Black soils are found in the Deccan trap (*Basalt*) region of Deccan plateau, the plateaus of Maharashtra, Madhya Pradesh and Chhattisgarh.
- Red soil develops on crystalline igneous rocks.
- Red and yellow soils are found in the eastern and southern parts of the Deccan plateau, the Western Ghats.
- The laterite soil develops due to intense leaching in areas with high temperature and heavy rainfall.
- Laterite soils are found in Karnataka, Kerala, Tamil Nadu, Madhya Pradesh, and the hilly areas of Orissa and Assam.
- The denudation of the soil cover and subsequent washing down is described as soil erosion.
- When the running water cuts through the clayey soils and makes deep channels it is called gullies.
- The land becomes unfit for cultivation and is known as bad land.

- In the Chambal basin such lands are called ravines.
- Sometimes water flows as a sheet over large areas down a slope. In such cases the top soil is washed away. This is known as sheet erosion.
- Wind blows loose soil off flat or sloping land known as wind erosion.

THE PLACE AND NATURE OF AGRICULTURE

Agriculture is the production of food and goods through farming. Agriculture was the key development that led to the rise of human civilization, with the husbandry of domesticated animals and plants (i.e. crops) creating food surpluses that enabled the development of more densely populated and stratified societies. The study of agriculture is known as agricultural science. Central to human society, agriculture is also observed in certain species of ant and termite.

Agriculture encompasses a wide variety of specialties and techniques, including ways to expand the lands suitable for plant raising, by digging water-channels and other forms of irrigation. Cultivation of crops on arable land and the pastoral herding of livestock on rangeland remain at the foundation of agriculture. In the past century there has been increasing concern to identify and quantify various forms of agriculture. In the developed world the range usually extends between sustainable agriculture (e.g. permaculture or organic agriculture) and intensive farming (e.g. industrial agriculture).

Modern agronomy, plant breeding, pesticides and fertilizers, and technological improvements have sharply increased yields from cultivation, and at the same time have caused widespread ecological damage and negative human health effects. Selective breeding and modern practices in animal husbandry such as intensive pig farming (and similar practices applied to the chicken) have similarly increased the output of meat, but have raised concerns about animal cruelty and the health effects of the antibiotics, growth hormones, and other chemicals commonly used in industrial meat production.

The major agricultural products can be broadly grouped into foods, fibers, fuels, and raw materials. In the 2000s, plants have been used to grow biofuels, biopharmaceuticals, bioplastics, and pharmaceuticals. Specific foods include cereals, vegetables, fruits, and meat. Fibers include cotton, wool, hemp, silk and flax. Raw materials include lumber and bamboo. Other useful materials are produced by plants, such as resins. Biofuels include methane from biomass, ethanol, and biodiesel. Cut flowers, nursery plants, tropical fish and birds for the pet trade are some of the ornamental products.

In 2007, about one third of the world's workers were employed in agriculture. The services sector has overtaken agriculture as the economic sector employing the most people worldwide. Despite the size of its workforce, agricultural production accounts for less than five percent of the gross world product (an aggregate of all gross domestic products).

Etymology

The word *agriculture* is the English adaptation of Latin *agricultural*, from *ager*, "a field", and *cultural*, "cultivation" in the strict sense of "tillage of the soil". Thus, a literal reading of the word yields "tillage of a field/of fields".

Overview

Agriculture has played a key role in the development of human civilization. Until the Industrial Revolution, the vast majority of the human population laboured in agriculture. Development of agricultural techniques has steadily increased agricultural productivity, and the widespread diffusion of these techniques during a time period is often called an agricultural revolution. A remarkable shift in agricultural practices has occurred over the past century in response to new technologies. In particular, the Haber-Bosch method for synthesizing ammonium nitrate made the traditional practice of recycling nutrients with crop rotation and animal manure less necessary.

Synthetic nitrogen, along with mined rock phosphate, pesticides and mechanization, have greatly increased crop yields in the early 20th century. Increased supply of grains has led to cheaper livestock as well.

Further, global yield increases were experienced later in the 20th century when high-yield varieties of common staple grains such as rice, wheat, and corn (maize) were introduced as a part of the Green Revolution. The Green Revolution exported the technologies (including pesticides and synthetic nitrogen) of the developed world to the developing world. Thomas Malthus famously predicted that the Earth would not be able to support its growing population, but technologies such as the Green Revolution have allowed the world to produce a surplus of food.

Many governments have subsidized agriculture to ensure an adequate food supply. These agricultural subsidies are often linked to the production of certain commodities such as wheat, corn (maize), rice, soybeans, and milk. These subsidies, especially when instituted by developed countries have been noted as protectionist, inefficient, and environmentally damaging. In the past century agriculture has been characterized by enhanced productivity, the use of synthetic fertilizers and pesticides, selective breeding, mechanization, water contamination, and farm subsidies. Proponents of organic farming such as Sir Albert Howard argued in the early 1900s that the overuse of pesticides and synthetic fertilizers damages the long-term fertility of the soil. While this feeling lay dormant for decades, as environmental awareness has increased in the 2000s there has been a movement towards sustainable agriculture by some farmers, consumers, and policymakers. In recent years there has been a backlash against perceived external environmental effects of mainstream agriculture, particularly regarding water pollution, resulting in the organic movement. One of the major forces behind this movement has been the European Union, which first certified organic food in 1991 and began reform of its Common Agricultural Policy (CAP) in 2005 to phase out commodity-linked farm subsidies, also known as decoupling. The growth of organic farming has renewed research in alternative technologies such as integrated pest management and selective breeding. Recent mainstream technological developments include genetically modified food.

In late 2007, several factors pushed up the price of grains consumed by humans as well as used to feed poultry and dairy cows and other cattle, causing higher prices of wheat (up 58%), soybean (up 32%), and maize (up 11%) over the year. Food riots took place in several countries across the world. Contributing factors included drought in Australia and elsewhere, increasing demand for grain-fed animal products from the growing middle classes of countries such as China and India, diversion of foodgrain to biofuel production and trade restrictions imposed by several countries.

An epidemic of stem rust on wheat caused by race Ug99 is currently spreading across Africa and into Asia and is causing major concern. Approximately 40% of the world's agricultural land is seriously degraded. In Africa, if current trends of soil degradation continue, the continent might be able to feed just 25% of its population by 2025, according to UNU's Ghana-based Institute for Natural Resources in Africa.

History

Since its development roughly 10,000 years ago, agriculture has expanded vastly in geographical coverage and yields. Throughout this expansion, new technologies and new crops were integrated. Even then crops were modified through cross-breeding for better yields. Agricultural practices such as irrigation, crop rotation, fertilizers, and pesticides were developed long ago, but have made great strides in the past century. The history of agriculture has played a major role in human history, as agricultural progress has been a crucial factor in worldwide socio-economic change. Wealth-concentration and militaristic specializations rarely seen in hunter-gatherer cultures are commonplace in societies which practice agriculture. So, too, are arts such as epic literature and monumental architecture, as well as codified legal systems. When farmers became capable of producing food beyond the needs of their own families, others in their society were freed to devote themselves to projects other than food acquisition. Historians and anthropologists have long argued that the development of agriculture made civilization possible.

Ancient Origins

The Fertile Crescent of Western Asia, Egypt, and India were sites of the earliest planned sowing and harvesting of plants that had previously been gathered in the wild. Independent development of agriculture occurred in northern and southern China, Africa's Sahel, New Guinea and several regions of the Americas. The eight so-called Neolithic founder crops of agriculture appear: first emmer wheat and einkorn wheat, then hulled barley, peas, lentils, bitter vetch, chick peas and flax.

By 7000 BC, small-scale agriculture reached Egypt. From at least 7000 BC the Indian subcontinent saw farming of wheat and barley, as attested by archaeological excavation at Mehrgarh in Balochistan. By 6000 BC, mid-scale farming was entrenched on the banks of the Nile. About this time, agriculture was developed independently in the Far East, with rice, rather than wheat, as the primary crop. Chinese and Indonesian farmers went on to domesticate taro and beans including mung, soy and azuki. To complement these new sources of carbohydrates, highly organized net fishing of rivers, lakes and ocean shores in these areas brought in great volumes of essential protein. Collectively, these new methods of farming and fishing inaugurated a human population boom that dwarfed all previous expansions and continues today.

By 5000 BC, the Sumerians had developed core agricultural techniques including large-scale intensive cultivation of land, monocropping, organized irrigation, and the use of a specialized labour force, particularly along the waterway now known as the Shatt al-Arab, from its Persian Gulf delta to the confluence of the Tigris and Euphrates. Domestication of wild aurochs and mouflon into cattle and sheep, respectively, ushered in the large-scale use of animals for food/fiber and as beasts of burden. The shepherd joined the farmer as an essential provider for sedentary and seminomadic societies. Maize, manioc, and arrowroot were first domesticated in the Americas as far back as 5200 BC. The potato, tomato, pepper, squash, several varieties of bean, tobacco, and several other plants were also developed in the New World, as was extensive terracing of steep hillsides in much of Andean South America. The Greeks and Romans built on techniques pioneered by the Sumerians, but made few fundamentally new advances. Southern Greeks struggled with very poor soils, yet managed to become a dominant society for years. The Romans were noted for an emphasis on the cultivation of crops for trade.

In the Americas, a parallel agricultural revolution occurred, resulting in some of the most important crops grown today. In Mesoamerica wild teosinte was transformed through human selection into the ancestor of modern maize, more than 6000 years ago. It gradually spread across North America and was the major crop of Native Americans at the time of European exploration. Other Mesoamerican crops include hundreds of varieties of squash and beans. Cocoa was also a major crop in domesticated Mexico and Central America. The turkey, one of the most important meat birds, was probably domesticated in Mexico or the U.S. Southwest. In the Andes region of South America the major domesticated crop was potatoes, domesticated perhaps 5000 years ago. Large varieties of beans were domesticated, in South America, as well as animals, including llamas, alpacas, and guinea pigs. Coca, still a major crop, was also domesticated in the Andes. A minor center of domestication, the indigenous people of the Eastern U.S. appear to have domesticated numerous crops. Sunflowers, tobacco, varieties of squash and Chenopodium, as well as crops no longer grown, including marshelder and little barley were domesticated. Other wild foods may have undergone some selective cultivation, including wild rice and maple sugar. The most common varieties of strawberry were domesticated from Eastern North America.

Middle Ages

During the Middle Ages, farmers in North Africa, the Near East, and Europe began making use of agricultural technologies including irrigation systems based on hydraulic and hydrostatic principles, machines such as norias, water-raising machines, dams, and reservoirs. This combined with the invention of a three-field system of crop rotation and the moldboard plow greatly improved agricultural efficiency.

Modern Era

After 1492, a global exchange of previously local crops and livestock breeds occurred. Key crops involved in this exchange included the tomato, maize, potato, manioc, cocoa bean and tobacco going from the New World to the Old, and several varieties of wheat, spices, coffee, and sugar cane going from the Old World to the New. The most important animal exportation from the Old World to the New were those of the horse and dog (dogs were already present in the pre-Columbian Americas but not in the numbers and breeds suited to farm work). Although not usually food animals, the horse (including donkeys and ponies) and dog quickly filled essential production roles on western-hemisphere farms.

The potato became an important staple crop in northern Europe. Since being introduced by Portuguese in the 16th century, maize and manioc have replaced traditional African crops as the continent's most important staple food crops.

By the early 1800s, agricultural techniques, implements, seed stocks and cultivated plants selected and given a unique name because of its decorative or useful characteristics had so improved that yield per land unit was many times that seen in the Middle Ages. With the rapid rise of mechanization in the late 19th and 20th centuries, particularly in the form of the tractor, farming tasks could be done with a speed and on a scale previously impossible. These advances have led to efficiencies enabling certain modern farms in the United States, Argentina, Israel, Germany, and a few other nations to output volumes of high-quality produce per land unit at what may be the practical limit. The Haber-Bosch method for synthesizing ammonium nitrate represented a major breakthrough and allowed crop yields to overcome previous constraints. In the past century agriculture has been characterized by enhanced productivity, the substitution of labour for synthetic fertilizers and pesticides, water pollution, and farm subsidies. In recent years there has been a backlash against the external environmental effects of conventional agriculture, resulting in the organic movement.

The cereals rice, corn, and wheat provide 60% of human food supply. Between 1700 and 1980, "the total area of cultivated land worldwide increased 466%" and yields increased dramatically, particularly because of selectively-bred high-yielding varieties, fertilizers, pesticides, irrigation, and machinery. For example, irrigation increased corn yields in eastern Colorado by 400 to 500% from 1940 to 1997.

However, concerns have been raised over the sustainability of intensive agriculture. Intensive agriculture has become associated with decreased soil quality in India and Asia, and there has been increased concern over the effects of fertilizers and pesticides on the environment, particularly as population increases and food demand expands. The monocultures typically used in intensive agriculture increase the number of pests, which are controlled through pesticides. Integrated pest management (IPM), which "has been promoted for decades and has had some notable successes" has not significantly affected the use of pesticides because policies encourage the use of pesticides and IPM is knowledge-intensive. Although the "Green

Revolution" significantly increased rice yields in Asia, yield increases have not occurred in the past 15–20 years. The genetic "yield potential" has increased for wheat, but the yield potential for rice has not increased since 1966, and the yield potential for maize has "barely increased in 35 years. It takes a decade or two for herbicide-resistant weeds to emerge, and insects become resistant to insecticides within about a decade. Crop rotation helps to prevent resistances.

Agricultural exploration expeditions, since the late nineteenth century, have been mounted to find new species and new agricultural practices in different areas of the world. Two early examples of expeditions include Frank N. Meyer's fruit-and nut-collecting trip to China and Japan from 1916-1918 and the Dorsett-Morse Oriental Agricultural Exploration Expedition to China, Japan, and Korea from 1929-1931 to collect soybean germplasm to support the rise in soybean agriculture in the United States.

In 2005, the agricultural output of China was the largest in the world, accounting for almost one-sixth of world share, followed by the EU, India and the USA, according to the International Monetary Fund. More than 40 million Chinese farmers have been displaced from their land in recent years usually for economic development, contributing to the 87,000 demonstrations and riots across China in 2005. Economists measure the total factor productivity of agriculture and by this measure agriculture in the United States is roughly 2.6 times more productive than it was in 1948.

Six countries-the US, Canada, France, Australia, Argentina and Thailand-supply 90% of grain exports. The United States controls almost half of world grain exports. Water deficits, which are already spurring heavy grain imports in numerous middle-sized countries, including Algeria, Iran, Egypt, and Mexico, may soon do the same in larger countries, such as China or India.

Climate Change

Climate change has the potential to affect agriculture through changes in temperature, rainfall (timing and quantity), CO_2, solar radiation and the interaction of these elements. Agriculture can both mitigate or worsen global warming. Some of the increase in CO_2 in the atmosphere comes from the decomposition of organic matter in the soil, and much of the methane emitted into the atmosphere is caused by the decomposition of organic matter in wet soils such as rice paddies. Further, wet or anaerobic soils also lose nitrogen through denitrification, releasing the greenhouse gas nitric oxide. Changes in management can reduce the release of these greenhouse gases, and soil can further be used to sequester some of the CO_2 in the atmosphere.

Distortions in Modern Global Agriculture

Differences in economic development, population density and culture mean that the farmers of the world operate under very different conditions.

A US cotton farmer may receive US$230 in government subsidies per acre planted (in 2003), while farmers in Mali and other third-world countries do without.

When prices decline, the heavily subsidised US farmer is not forced to reduce his output, making it difficult for cotton prices to rebound, but his Mali counterpart may go broke in the meantime.

A livestock farmer in South Korea can calculate with a (highly subsidized) sales price of US.74.7 for a calf produced. A South American Mercosur country rancher calculates with a calf's sales price of US$120–200 (both 2008 figures).

With the former, scarcity and high cost of land is compensated with public subsidies, the latter compensates absence of subsidies with economics of scale and low cost of land.

In the Peoples Republic of China, a rural household's productive asset may be one hectare of farmland. In Brazil, Paraguay and other countries where local legislature allows such purchases, international investors buy thousands of hectares of farmland or raw land at prices of a few hundred US$ per hectare.

Agricultural Subsidy

An agricultural subsidy is a governmental subsidy paid to farmers and agribusinesses to supplement their income, manage the supply of agricultural commodities, and influence the cost and supply of such commodities. Examples of such commodities include wheat, feed grains (grain used as fodder, such as maize, sorghum, barley, and oats), cotton, milk, rice, peanuts, sugar, tobacco, and oilseeds such as soybeans.

OBJECTIVES OF MARKET INTERVENTION

National Security

Some argue that nations have an interest in assuring there is sufficient domestic production capability to meet domestic needs in the event of a global supply disruption. Significant dependence on foreign food producers makes a country strategically vulnerable in the event of war, blockade or embargo. Maintaining adequate domestic capability allows for food self-sufficiency that lessens the risk of supply shocks due to geopolitical events.

Agricultural policies may be used to support domestic producers as they gain domestic and international market share.

This may be a short term way of encouraging an industry until it is large enough to thrive without aid. Or it may be an ongoing subsidy designed to allow a product to compete with or undercut foreign competition. This may produce a net gain for a government despite the cost of interventions because it allows a country to build up an export industry or reduce imports. It also helps to form the nations supply and demand market.

Environmental Protection and Land Management

Farm or undeveloped land composes the majority of land in most countries. Policies may encourage some land uses rather than others in the interest of protecting the environment. For instance, subsidies may be given for particular farming methods, forestation, land clearance, or pollution abatement.

Rural poverty and Poverty Relief

Subsidising farming may encourage people to remain on the land and obtain some income. This might be relevant to a third world country with many peasant farmers, but it may also be a consideration to more developed countries such as Poland. They have a very high unemployment rate, much farmland and retain a large rural population growing food for their own use. Price controls may also be used to assist poor citizens. Many countries have used this method of welfare support as it delivers cheap food to the poorest without the need to assess people to give them financial aid.

Organic Farming Assistance

Welfare economics theory holds that sometimes private activities can impose social costs upon others. Industrial agriculture is widely considered to impose social costs through pesticide pollution and nitrate pollution.

Further, agriculture uses large amounts of water, a scarce resource. Some economists argue that taxes should be levied on agriculture, or that organic agriculture, which uses little pesticides and experiences relatively little nitrate runoff, should be encouraged with subsidies. In the United States, 65% of the approximately $16.5 billion in annual subsidies went to the top 10% of farmers in 2002 because subsidies are linked to certain commodities. On the other hand, organic farming received $5 million for help in certification and $15 million for research over a 5-year time period.

Fair Trade

Some advocate Fair Trade rules to ensure that poor farmers in developing nations that produce crops primarily for export are not exploited or outcompeted-which advocates consider a dangerous "race to the bottom" in agricultural labour and safety standards. Opponents point out that most agriculture in developed nations is produced by industrial corporations (agribusiness) which are hardly deserving of sympathy, and that the alternative to exploitation is poverty.

ARGUMENTS AGAINST MARKET INTERVENTION

Dumping of Agricultural Surpluses

In international trade parlance, when a company from country A sells a commodity below the cost of production into country B, this is called "dumping". A number of countries that are signatories to multilateral trade agreements have provisions that prohibit this practice. When rich countries subsidize domestic production, excess output is often given to the developing world as foreign aid. This process eliminates the domestic market for agricultural products in the developing world, because the products can be obtained for free from western aid agencies. In developing nations where these effects are most severe, small farmers could no longer afford basic inputs and were forced to sell their land.

"Consider a farmer in Ghana who used to be able to make a living growing rice. Several years ago, Ghana was able to feed and export their surplus. Now, it imports rice. From where? Developed countries. Why? Because it's cheaper. Even if it costs the rice producer in the developed world much more to produce the rice, he doesn't have to make a profit from his crop. The government pays him to grow it, so he can sell it more cheaply to Ghana than the farmer in Ghana can. And that farmer in Ghana? He can't feed his family anymore." (Lyle Vanclief, Former Canadian Minister of Agriculture [1997-2003]).

According to The Institute for Agriculture and Trade Policy, corn, soybeans, cotton, wheat and rice are sold below the cost of production, or dumped. Dumping rates are approximately forty percent for wheat, between twenty-five and thirty percent for corn (maize), approximately thirty percent for soybeans, fifty-seven percent for cotton, and approximately twenty percent for rice. For example, wheat is sold for forty percent below cost.

According to Oxfam, "If developed nations eliminated subsidy programs, the export value of agriculture in lesser developed nations would increase by 24%, plus a further 5.5% from tariff equilibrium.... exporters can offer US surpluses for sale at prices around half the cost of production; destroying local agriculture and creating a captive market in the process." Free trade advocates desire the elimination of all market distorting mechanisms (subsidies, tariffs, regulations) and argue that, as with free trade in all areas, this will result in aggregate benefit for all. This position is particularly popular in competitive agricultural exporting nations in both the developed and developing world, some of whom have banded together in the Cairns Group lobby. Canada's Department of Agriculture estimates that developing nations would benefit by about $4 billion annually if subsidies in the developed world were halved.

Agricultural Independence

Many developing countries do not grow enough food to feed their own populations. These nations must buy food from other countries. Lower prices and free food save the lives of millions of starving people, despite the drop in food sales of the local farmers. A developing nation could use new improved farming methods to grow more food, with the ultimate goal of feeding their nation without outside help. New greenhouse methods, hydroponics, fertilizers, R/O Water Processors, hybrid crops, fast-growing hybrid trees for quick shade, interior temperature control, greenhouse or tent insulation, autonomous building gardens, sun lamps, mylar, fans, and other cheap tech can be used to grow crops on previously unarable land, such as rocky, mountainous, desert, and even Arctic lands. More food can be grown, reducing dependency on other countries for food.

Replacement crops can also make nations agriculturally independent. Sugar, for example, comes from sugar cane imported from Polynesia. Instead of buying the sugar from Polynesia, a nation can make sugar from sugar beets, maple sap, or sweetener from stevia plant, keeping the profits circulating within the nation's economy. Paper and clothes can be made of hemp instead of trees and cotton. Tropical foods won't grow in many places in Europe, but they will grow in insulated greenhouses or tents in Europe. Soybean plant cellulose can replace plastic (made from oil). Ethanol from farm waste or hempseed oil can replace gasoline. Rainforest medicine plants grown locally can replace many imported medicines. Alternates of cash crops, like sugar and oil replacements can reducing the farmer's dependency on subsidies in both developed and developing nations.

Market interventions may increase the cost to consumers for agricultural products, either via hidden wealth transfers via the government, or increased prices at the consumer level, such as for sugar and peanuts in the US. This has led to market distortions, such as food processors using high fructose corn syrup as a replacement for sugar. High fructose corn syrup may be an unhealthy food additive, and, were sugar prices not inflated by government fiat, sugar might be preferred over high fructose corn syrup in the marketplace.

DEVELOPED WORLD CASES

Overview: Europe and America

The farmer population is approximately five percent of the total population in the E.U. and 1.7% in the U.S. The total value of agricultural production in the E.U. amounted to 128 billion euros (1998). About forty-nine percent of this amount was accounted for by political measures: 37 billion euros due to direct payments and 43 billion euros from consumers due to the artificially high price. Eighty percent of European farmers receive a direct payment of 5,000 euros or less, while 2.2% receive a direct payment above 50,000 euros, totalling forty percent of all direct subsidies.

The average U.S. farmer receives $16,000 in annual subsidies. Two-thirds of farmers receive no direct payments. Of those that do, the average amount amongst the lowest paid eighty percent was $7000 from 1995-2003. Subsidies are a mix of tax reductions, direct cash payments and below-market prices on water and other inputs. Some claim that these aggregate figures are misleading because large agribusinesses, rather than individual farmers, receive a significant share of total subsidy spending.

The Federal Agriculture Improvement and Reform Act of 1996 reduced farm subsidies, providing fixed payments over a period and replacing price supports and subsidies. The Farm Security and Rural Investment Act of 2002 contains direct and countercyclical payments designed to limit the effects of low prices and yields.

In the EU, € 54 billion of subsidies are paid every year. An increasing share of the subsidies is being decoupled from production and lumped into the Single Farm Payment. While this has diminished the distortions created by the Common Agricultural Policy, many critics argue that a greater focus on the provision of public goods, such as biodiversity and clean water, is needed. The next major reform is expected for 2014, when a new long-term EU budget is coming into effect.

Environmental Programs

The U.S. Conservation Reserve Program leases land from producers that take marginal land out of production and convert it back to a near-natural state by planting native grasses and other plants. The U.S. Environmental Quality Incentives Program subsidizes improvements which promote water conservation and other measures. This program is conducted under a bidding process using a formula where farmers request a certain percentage of cost share for an improvement such as drip irrigation. Producers that offer the most environmental improvement based on a point system for the least cost are funded first. The process continues until that year's allocated funds are expended.

World Trade Organization Actions

In April 2004 the WTO ruled that 3-billion dollars in US cotton subsidies violate trade agreements and that almost 50% of EU sugar exports are illegal. In 1997-2003, US cotton exports were subsidized by an average of 48%. The World Trade Organization (WTO) has extracted commitments from the Philippines government, making it lower import barriers to half their present levels over a span of six years, and allowing in drastically increased competition from the industrialised and heavily subsidised farming systems of North America and Europe. A recent Oxfam report estimated that average household incomes of maize farmers will be reduced by as much as 30% over the six years as cheap imports from the US drive down prices in the local markets. The report estimates that in the absence of trade restrictions, US subsidised maize could be marketed at less than half the price of maize grown on the Philippine island of Mindanao; and that the livelihoods of up to half a million Filipino maize farmers (out of the total 1.2 million) are under immediate threat.

6

Human Geography

Introduction

Human geography is a branch of geography that focuses on the study of patterns and processes that shape human interaction with various environments. It encompasses human, political, cultural, social, and economic aspects.

While the major focus of human geography is not the physical landscape of the Earth, it is hardly possible to discuss human geography without referring to the physical landscape on which human activities are being played out, and environmental geography is emerging as a link between the two. Human geography can be divided into many broad categories, such as:

- Cultural geography
- Development geography
- Economic geography Health geography
- Historical & Time geog.
- Political geog. & Geopolitics
- Pop. geog. or Demography
- Religion geography
- Social geography
- Transportation geography
- Tourism geography
- Urban geography

Various approaches to the study of human geography have also arisen through time and include:

- Behavioral geography
- Feminist geography
- Culture theory
- Geosophy

HEALTH GEOGRAPHY

Health geography is the application of geographical information, perspectives, and methods to the study of health, disease, and health care.

Adopting a socio-ecological rather than the bio-medical model, health geography adopts a more holistic approach, emphasizing treatment of the whole person and not just components of the system. Under this model, new illnesses (e.g., mental ill health) are recognised, and other types of medicine (e.g., complementary or alternative medicine) are combined with traditional medicine.

This alternative methodological approach means that medical geography is broadened to incorporate philosophies such as structuration, structuralism, social interactionism, feminism, et cetera. Thus the field of health geography was born.

History of Health Geography

A classic piece of research in health geography was done in 1854 as cholera gripped London. Death tolls rang around the clock and the people feared that they were being infected by vapors coming from the ground. Dr. John Snow thought that if he could locate the source of the disease, it could be contained. He drew maps showing the homes of people who had died of cholera and the locations of water pumps. He found that one pump, the public pump on Broad Street, was central to most of the victims. He figured that infected water from the pump was the culprit. He instructed the authorities to remove the handle to the pump, making it unusable. After that the number of new cholera cases decreased.

Areas of Study

Health geography can provide a spatial understanding of a population's health, the distribution of disease in an area, and the environment's effect on health and disease deals also with accessibility to health care and spatial distribution of health care providers. The study is considered a subdiscipline of human geography, however, it requires an understanding of other fields such as epidemiology, climatology.

Geography of Health Care Provision

Although health care is a public good, it is not 'pure'. In other words, it is not equally available to all individuals. The geography of health care provision has much to do with this. Demand for public services is continuously distributed across space, broadly in accordance with the distribution of population, but these services are only provided at discrete locations. Inevitably therefore, there will be inequalities of access in terms of the practicality of using services, transport costs, travel times and so on. Geographical or 'locational' factors (e.g. physical proximity, travel time) are not the only aspects which influence access to health care. Other types (or dimensions) of accessibility to health care except for geographical (or spatial) are social, financial and functional. *Social* accessibility to health care depends on race (like separate hospitals for white and black people), age, sex and other social characteristics of individuals, important here is also relationship between patient and the doctor. *Financial* depends upon the price of a particular health care and *functional* reflects the amount and structure of provided services. This can vary among different countries or regions of the world. Access to health care is influenced also by factors such as opening times and waiting lists that play an important part in determining whether individuals or population sub-groups can access health care – this type of accessibility is termed 'effective accessibility'.

The location of health care facilities depends largely on the nature of the health care system in operation, and will be heavily influenced by historical factors due to the heavy investment costs in facilities such as hospitals and surgeries. Simple distance will be mediated by organisational factors such as the existence of a referral system by which patients are directed towards particular parts of the hospital sector by their GP.

Access to primary care is therefore a very significant component of access to the whole system. In a 'planned' health care system, we would expect the distribution of facilities to fairly closely match the distribution of demand.

By contrast, a market-oriented system might mirror the locational patterns that we find in other business sectors, such as retail location. We may attempt to measure either *potential accessibility* or *revealed accessibility*, but we should note that there is a well-established pattern of utilisation increasing with access, i.e. people who have easier access to health care use it more often.

Health Geographers

Notable Health Geographers Include:

- Jonathan Mayer
- Melinda Meade
- Ellen Cromley
- Anthony C. Gatrell
- Jim Dunn
- Robin Kearns
- Sara McLafferty
- Graham Moon
- Gerard Rushton
- W.F. (Ric) Skinner

Historical Geography

Historical geography is the study of the human, physical, fictional, theoretical, and "real" geographies of the past. Historical geography studies a wide variety of issues and topics. A common theme is the study of the geographies of the past and how a place or region changes through time. Many historical geographers study geographical patterns through time, including how people have interacted with their environment, and created the cultural landscape. Historical geography seeks to determine how cultural features of various societies across the planet emerged and evolved, by understanding their interaction with their local environment and surroundings.

For some in the United States, the term *historical geography* has a more specialized meaning: the name given by Carl Ortwin Sauer of the University of California, Berkeley to his program of reorganizing cultural geography (some say all geography) along regional lines, beginning in the first decades of the 20th century. To Sauer, a landscape and the cultures in it could only be understood if all of its influences through history were taken into account: physical, cultural, economic, political, environmental.

Sauer stressed regional specialization as the only means of gaining sufficient expertise on regions of the world. Sauer's philosophy was the principal shaper of American geographic thought in the mid-20th century. Regional specialists remain in academic geography departments to this day. But some geographers feel that it harmed the discipline; that too much effort was spent on data collection and classification, and too little on analysis and explanation. Studies became more and more area-specific as later geographers struggled to find places to make names for themselves. These factors may have led in turn to the 1950s crisis in geography, which raised serious questions about geography as an academic discipline in the United States.

POLITICAL GEOGRAPHY

Political geography is the field of human geography that is concerned with the study of both the spatially uneven outcomes of political processes and the ways in which political processes are themselves affected by spatial structures. Conventionally political geography adopts a three-scale structure for the purposes of analysis with the study of the state at the centre, above this is the study of international relations (or geopolitics), and below it is the study of localities. The primary concerns of the sub-discipline can be summarised as the inter-relationships between people, state, and territory.

History

The origins of political geography lie in the origins of human geography itself and the early practitioners were concerned mainly with the military and political consequences of the relationships between physical geography, state territories, and state power. In particular there was a close association with regional geography, with its focus on the unique characteristics of regions, and environmental determinism with its emphasis on the influence of the physical environment on human activities. This association found expression in the work of the German geographer Friedrich Ratzel who, in 1897 in his book *Politische Geographie*, developed the concept of Lebensraum (living space) which explicitly linked the cultural growth of a nation with territorial expansion, and which was later used to provide academic legitimation for the imperialist expansion of the German Third Reich in the 1930s.

The British geographer Halford Mackinder was also heavily influenced by environmental determinism and in developing his concept of the 'geopolitical pivot of history' or heartland (first developed in 1904) he argued that the era of sea power was coming to an end and that land based powers were in the ascendant, and, in particular, that whoever controlled the heartland of 'Euro-Asia' would control the world. This theory involved concepts diametrically opposed to the ideas of Alfred Thayer Mahan about the significance of *sea power* in world conflict. The heartland theory hypothesized the possibility of a huge empire being created which didn't need to use coastal or transoceanic transport to supply its military industrial complex, and that this empire could not be defeated by the rest of the world coalitioned against it. This perspective proved influential throughout the period of the Cold War, underpinning military thinking about the creation of buffer states between East and West in central Europe.

The heartland theory depicted a world divided into a *Heartland* (Eastern Europe/Western Russia); *World Island* (Eurasia and Africa); *Peripheral Islands* (British Isles, Japan, Indonesia and Australia) and *New World* (The Americas). Mackinder claimed that whoever controlled the Heartland would have control of the world. He used this warning to politically influence events such as the Treaty of Versailles, where buffer states were created between the USSR and Germany, to prevent either of the them controlling the Heartland. At the same time, Ratzel was creating a theory of states based around the concepts of Lebensraum and Social Darwinism. He argued that states were 'organisms' that needed sufficient room in which to live. Both of these writers created the idea of a political and geographical science, with an objective view of the world. Pre-World War II political geography was concerned largely with these issues of global power struggles and influencing state policy, and the above theories were taken on board by German geopoliticians such as Karl Haushofer who-perhaps inadvertently-greatly influenced Nazi political theory. A form of politics legitimated by 'scientific' theories such as a 'neutral' requirement for state expansion was very influential at this time.

The close association with environmental determinism and the freezing of political boundaries during the Cold War led to a considerable decline in the importance of political geography which was described by Brian Berry in 1968 as 'a moribund backwater'. Although in other areas of human geography a number of new approaches were invigorating research, including quantitative spatial science, behavioural studies, and structural marxism, these were largely ignored by political geographers whose main point of reference continued to be the regional approach. As a result much political geography of this period was descriptive with little attempt to produce generalisations from the data collected. It was not until 1976 that Richard Muir could argue that political geography might not be a dead duck but could in fact be a phoenix.

Areas of Study

From the late-1970s onwards political geography has undergone a renaissance, and could fairly be described as one of the most dynamic of the sub-disciplines today. The revival was underpinned by the launch of the journal Political Geography Quarterly (and its expansion to bimonthly production as Political Geography). In part this growth has been associated with the adoption by political geographers of the approaches taken up earlier in other areas of human geography, for example, Ron J. Johnston's (1979) work on electoral geography relied heavily on the adoption of quantitative spatial science, Robert Sack's (1986) work on territoriality was based on the behavioural approach, and Peter Taylor's (e.g. 2007) work on World Systems Theory owes much to developments within structural Marxism. However the recent growth in the vitality and importance of the sub-discipline is also related to changes in the world as a result of the end of the Cold War, including the emergence of a new world order (which as yet is only poorly defined), and the development of new research agendas, such as the more recent focus on social movements and political struggles going beyond the study of nationalism with its explicit territorial basis.

Recently, too, there has been increasing interest in the geography of green politics, including the geopolitics of environmental protest, and in the capacity of our existing state apparatus and wider political institutions to address contemporary and future environmental problems competently.

Political geography has extended the scope of traditional political science approaches by acknowledging that the exercise of power is not restricted to states and bureaucracies, but is part of everyday life.

This has resulted in the concerns of political geography increasingly overlapping with those of other human geography sub-disciplines such as economic geography, and, particularly, with those of social and cultural geography in relation to the study of the politics of place.

Although contemporary political geography maintains many of its traditional concerns the multi-disciplinary expansion into related areas is part of a general process within human geography which involves the blurring of boundaries between formerly discrete areas of study, and through which the discipline as a whole is enriched.

In particular, then, modern political geography often considers:

- How and why states are organized into regional groupings, both formally (e.g. the European Union) and informally (e.g. the Third World)
- The relationship between states and former colonies, and how these are propagated over time, for example through neo-colonialism
- The relationship between a government and its people
- The relationships between states including international trades and treaties
- The functions, demarcations and policings of boundaries
- How imagined geographies have political implications
- The influence of political power on geographical space
- The study of election results (electoral geography)

MILITARY GEOGRAPHY

Military geography is a sub-field of geography that is used by, not only the military, but also academics and politicians to understand the geopolitical sphere through the militaristic lens. Following the Second World War, Military Geography has become the “application of geographic tools, information, and techniques to solve military problems in peacetime or war.” To accomplish these ends, military geographers must consider diverse geographical topics from geopolitics to the physical locations’ influences on military operations and from the cultural to the economic impacts of a military presence. Military Geography is the most thought-of tool for geopolitical control imposed upon territory.

Without the framework that the military geographer provides, a commander’s decision-making process is cluttered with multiple inputs from environmental analysts, cultural analysts, and many others. Without the military geographer to put all of the components together, a unit might know of the terrain, but not the drainage system below the surface. In that scenario, the unit would be at a disadvantage if the enemy would have chosen that drainage system as a point to ambush the unit as it passed through the area. The complexities of the battlefield are multiplied tenfold when military operations are to take place within the boundaries of areas of urban development. “If a general desired to be a successful actor in the great drama of war, his first duty is to study carefully the theater of operations so that he may see clearly the relative advantages and disadvantages it presents for himself and his enemies.”

Urbanistics

Due to the highly complex problems that urban development have given the military geographer, a term has been coined by Russian Colonel N.S. Olesik that can be applied to any military’s geography unit responsible for analysing the urban environment: “military geo-urbanistics.” Fighting in the open country is much simpler; all that there is to deal with is the terrain, weather, and the enemy. However, urban combat involves much more than the weather, enemy, and terrain. The terrain is even more complex within urban areas, filled with many structures and transformations of the land by the inhabitants. Also, within urban areas the geographer must work with or work around the people. No matter the situation, there are always people that will cooperate. Likewise there are always those that will oppose, and there are also those that are caught between the two factions. The difficulties for any military conducting operations within urban areas begin with the man-made structures that are what make an area urban. The different buildings themselves bring forth their own difficulties; obviously, this is due to the different types of structures that make up an urban area. The most dangerous aspect of urban warfare for U.S. troops, the roadside bomb, has become a deadly reality because of the narrow streets that convoys must use to get from one point to another within the confines of urban areas. Ambushes are more likely to be set up in or around heavily populated areas rather than the larger "industrial" locales that urban areas are set up around. In today's wars this is common practice for guerrilla warriors often due to a western nation's unwillingness to bomb a neighbourhood or hospital. In an urban area, especially cities, the dominance of air power is limited by the buildings' ability to restrict visibility from the air and because of the possible collateral damage.

During an urban operation it is almost impossible for there not to be any collateral damage; the people are just too close to the action. Also, with the theater of urban combat, there are some people that will oppose the invading force, and sometimes that opposition will be armed opposition. The armed opposition, of course, makes it very difficult to identify enemy combatants from civilians. This is the case in the ongoing Iraq war. In many cases occupying troops fight residents of the cities they are occupying. Insurgents often conceal themselves in the rest of the population and may employ vehicle bombs and suicide bombing.

Base Construction and Closings

The United States Department of Defence maintains a larger number of domestic and foreign military bases than all other countries combined. Closing redundant military bases in the United States often has a negative economic impact on local communities. Analysts at the Pentagon respond to budget limitations by identifying installations that have become obsolete for various reasons. Sometimes the needs for the location are no longer prevalent in defence strategies or the installation's facilities have fallen into disrepair. That is the case with the smaller Reserve and National Guard facilities that dot every state. The personnel on the committees responsible for determining closures also observe the economic impact that their decisions will have on the communities surrounding the installations. If 40,000 people are employed because of the installation, either directly or indirectly, it is more likely that facility will remain open, but only if there is nowhere for the 40,000 people that would lose their jobs. Those people could end up on welfare, thus becoming just as much of a draw on revenue as they were as employees.

Outside of the United States, some countries are strongly vying for inclusion in strategic treaties such as NATO. These countries, many of which are in Eastern Europe, want to join NATO for the mutual advantages of defence and the possibility for foreign bases to be constructed on their soil. These bases, if they were to be built, would bring fiscal resources that those nations would not get without the bases. Sometimes foreign bases are viewed as a good thing. In other regions, a strong political stance may be taken against the construction of foreign military bases, often for sovereignty issues.

Types of Terrain

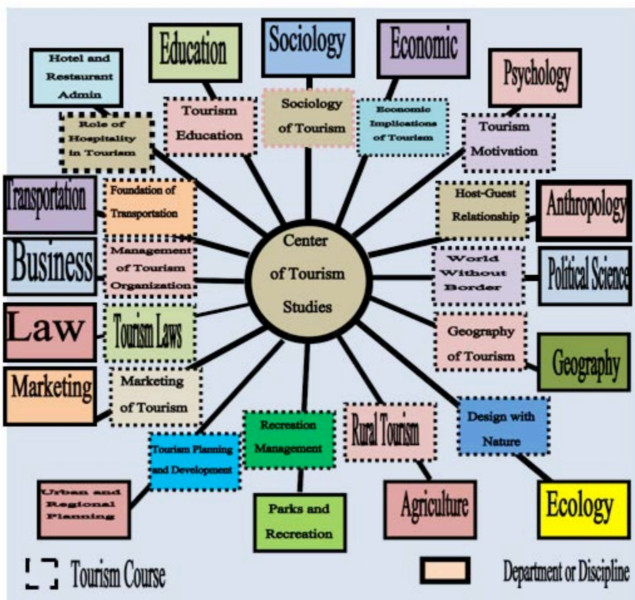
The following categories are different generic forms of combat that are the most prevalent in today's ongoing wars and are also anticipated to be the fields of battle in future conflicts. Each category has a unique climate that provides combatants with different obstacles. It is no longer as simple as "the high ground controls the low ground."

Desert Warfare

The climate in this category is obviously an arid one. In many desert areas across the globe, the sand is a main concern. The sand can hamper an army's attempts to remain hydrated because it can sap the moisture from your skin. The sand is also very notorious for jamming the firing mechanisms for most firearms. The terrain is usually fairly flat, though in some regions there are vast, rolling sand dunes. The desert environment can also contain mountains; such is the case in Afghanistan and in certain areas around Israel. Due to the ongoing conflicts in the Middle East, the U.S. Military has redesigned the uniforms for the different branches of service. All of the uniforms have a digital camouflage pattern that is very effective in the desert environment, and the boots have been changed from the standard polished black boots to a light brown coloured suede leather boots. These boots are a lot cooler under the intense heat of the desert sun.

TOURISM GEOGRAPHY

Tourism Geography is the study of travel and tourism, as an industry and as a social and cultural activity. Tourism geography covers a wide range of interests including the environmental impact of tourism, the geographies of tourism and leisure economies, answering tourism industry and management concerns and the sociology of tourism and locations of tourism. Tourism geography is that branch of science which deals with the study of travel and its impact on places.



Study of Tourism : Choice of Discipline and Approach (Source: Jafar Jafari, University of Wisconsin-Stout)

Geography is fundamental to the study of tourism, because tourism is geographical in nature. Tourism occurs in places, it involves movement and activities between places and it is an activity in which both place characteristics and personal self-identities are formed, through the relationships that are created among places, landscapes and people. Physical geography provides the essential background, against which tourism places are created and environmental impacts and concerns are major issues, that must be considered in managing the development of tourism places.

The approaches to study will differ according to the varying concerns. Much tourism management literature remains quantitative in methodology and considers tourism as consisting of the places of tourist origin (or tourist generating areas), tourist destinations (or places of tourism supply) and the relationship (connections) between origin and destination places, which includes transportation routes, business relationships and traveller motivations. Recent developments in Human geography have resulted in approaches such as those from cultural geography, which take more theoretically diverse approaches to tourism, including a sociology of tourism, which extends beyond tourism as an isolated, exceptional activity and considering how travel fits into the everyday lives and how tourism is not only a consumptive of places, but also produces the sense of place at a destination.

Transportation Geography

Transportation Geography is the branch of geography that investigates spatial interactions, let them be of people, freight and information. It can consider humans and their use of vehicles or other modes of travelling as well as how markets are serviced by flows of finished goods and raw materials. It is a branch of Economic geography.

“The ideal transport mode would be instantaneous, free, have an unlimited capacity and always be available. It would render space obsolete. This is obviously not the case. Space is a constraint for the construction of transport networks. Transportation appears to be an economic activity different from others. It trades space with time and thus money” (translated from [Merlin, 1992]).

Geography and transportation intersect in terms of the movement of peoples, goods, and information. Over time, accessibility has increased and this has led to a greater reliance on mobility. This trend could be traced back to the industrial revolution although it has significantly accelerated in the second half of the 20th century for various reasons. Today, societies rely on transport systems to support a wide variety of activities. These activities include commuting, supplying energy needs, distributing goods, and acquiring personal wants. The development of sufficient transport networks has been a continuous challenge to meet growing economic development, mobility needs, and ultimately to participate in the global economy.

Transport and urban geography are closely intertwined, with the concept of ribbon development being closely aligned to urban and transport studies. As humans increasingly seek to travel the world, the relationship transport and urban areas have often become obscured.

Transportation geography measures the result of human activity between and within locations. It focuses on items such as travel time, routes undertaken, modes of transport, resource use and sustainability of transport types on the natural environment. Other sections consider topography, safety aspects of vehicle use and energy use within an individual's or group's journey.

The purpose of transportation is to overcome space which is shaped by both human and physical constraints such as distance, political boundaries, time and topographies. The specific purpose of transportation is to fulfill a demand for mobility, since it can only exist if it moves something, be it people or goods. Any kind of movement must consider its geographical setting, and then choose an available form of transport based on cost, availability, and space.

TRANSPORTATION MODES

In terms of transport modes, the primary forms are air, rail, road, and water. Each one has its own cost associated with; speed of movement as a result of friction, and the place of origin and destination. For moving large amounts of goods, ships are generally utilized. Maritime shipping is able to carry more at a cheaper price around the world. For moving people who prefer to minimize travel time, and maximize comfort and convenience, air and road are the most common modes in usage. Rail road is often utilized to transport goods in areas away from water. Also water transportation is based upon early constructioning from railroad. "Transportation modes are an essential component of transport systems since they are the means by which mobility is supported. Geographers consider a wide range of modes that may be grouped into three broad categories based on the medium they exploit: land, water and air. Each mode has its own requirements and features, and is adapted to serve the specific demands of freight and passenger traffic. This gives rise to marked differences in the ways the modes are deployed and utilized in different parts of the world. Recently, there is a trend towards integrating the modes through intermodality and linking the modes ever more closely into production and distribution activities. At the same time, however, passenger and freight activity is becoming increasingly separated across most modes."

Road Transportation

Transportation using road networks are the type of transportation that are connected with movements on constructed roads, carrying people and goods from one place to another on the means of transportation like lorries, cars etc.

Rail Transportation

Transportation by use of rail, restricted to where rails have been built.

Maritime Transportation

Transportation over water, the slowest current form in the movement of goods/people.

Problems with Transportation Geography

Traffic and transportation in existing streets and highways and rail facilities no longer match the new demands created by recent population growth and new location patterns of economic activity. Besides increase in population, another problem is private automobiles overloading the network of highways and arterial streets.

URBAN GEOGRAPHY

Urban geography is the study of urban areas. That is the study of areas which have a high concentration of buildings and infrastructure. These are areas where the majority of economic activities are in the secondary sector and tertiary sectors. They often have a high population density.

Urban geography is that branch of science, which deals the study of urban areas, in terms of concentration, infrastructure, economy, and environmental impacts.

It can be considered a part of the larger field of human geography. However, it can often overlap with other fields such as anthropology and urban sociology. Urban geographers seek to understand how factors interact over space, what function they serve and their interrelationships.

Urban geographers also look at the development of settlements. Therefore, it involves planning city expansion and improvements. Urban geography, then, attempts to account for the human and environmental impacts of the change. Urban geography focuses on the city in the context of space throughout countries and continents.

Urban geography forms the theoretical basis for a number of professions including urban planning, site selection, real estate development, crime pattern analysis and logistical analysis.

Areas of Study

There are essentially two approaches to urban geography. The study of problems relating to the spatial distribution of cities themselves and the complex patterns of movement, flows and linkages that bind them in space.

Studies in this category are concerned with the *city system*. Secondly there is the study of patterns of distribution and interaction within cities, essentially the study of their inner structure.

Studies in this category are concerned with the *city as a system*. A succinct way to define urban geography that recognizes the link between these two approaches within the subject is then, that "urban geography is the study of cities as systems within a system of cities."

Site and Situation

Site describes the location of a city with respect to its soil, water supply and relief, or more still the actual point on which a settlement is built while situation describes the surrounding area of the city such as other settlements, rivers, mountains and communication.

Locations for cities are usually chosen for good reasons. Benefits of certain locations can include:

- A wet area: water is a constant necessity for urban areas and is difficult to transport. For this reason many cities are located near or adjacent to rivers.
- A dry area: in wet areas a dry area offers protection from flooding and marshland.
- Easy access to building materials: stone, wood or clay are necessary for the construction of cities and are difficult to transport long distances.
- A strategic defensive position: historically many cities have been constructed on high ground in order to make attack more difficult and to give a good view of surrounding land (for example, Quebec City). River meanders are also used as partial moats. Some cities were also built in swampy areas for the same reason (for example, Paris).
- Fuel supply: most cities were initially constructed near wood for burning and cooking. Today many cities are constructed near coal, oil and gas mines to make use of those resources (for example: Newcastle, Glasgow, Pittsburgh, Essen).
- A food supply: cities need some nearby land to be suitable for animal grazing or crop growing.
- A travel intersection point and bridging points: it is often useful for a city to be located at the intersection of rivers, roads or train lines in order to facilitate travel and trade. Bridging points are shallow areas that allow easy construction of bridges, (for example: London, Cologne).
- Historically many cities grew at so-called “break-of-bulk” points along navigable rivers, where a local obstacle

such as rapids required trade goods to be trans-shipped from larger boats to smaller boats, for example: Chicago, Montreal.

- Shelter and aspect: it is desirable to construct cities located on the side of a slope that is protected from incoming winds, and in a direction that receives maximum sun exposure.

CITIES AS CENTRES OF MANUFACTURING AND SERVICES

Cities differ in their economic makeup, their social and demographic characteristics and the roles they play within the city system. These differences can be traced back to regional variations in the local resources on which growth was based during the early development of the urban pattern and in part the subsequent shifts in the competitive advantage of regions brought about by changing locational forces affecting regional specialization within the framework of the market economy. Recognition of different city types necessitates their classification, and it is to this important aspect of urban geography that we now turn. Emphasis is on *functional town classification* and the basic underlying dimensions of the city system.

The purpose of classifying cities is twofold. On the one hand, it is undertaken in order to search reality for hypotheses. In this context, the recognition of different types of cities on the basis of, for example, their functional specialization may enable the identification of spatial regularities in the distribution and structure of urban functions and the formulation of hypotheses about the resulting patterns.

On the other hand, classification is undertaken to structure reality in order to test specific hypotheses that have already been formulated. For example, to test the hypotheses that cities with a diversified economy grow at a faster rate then those with a more specialized economic base, cities must first be classified so that diversified and specialized cities can be differentiated.

The simplest way to classify cities is to identify the distinctive role they play in the city system. There are three distinct roles.

1. *Central places* functioning primarily as service centres for local hinterlands.

2. *Transportation* cities performing break-of-bulk and allied functions for larger regions.

3. *Specialized-function* cities are dominated by one activity such as mining, manufacturing or recreation and serving national and international markets. The composition of a cities labour force has traditionally been regarded as the best indicator of functional specialization, and different city types have been most frequently identified from the analysis of employment profiles. Specialization in a given activity is said to exist when employment in it exceeds some critical level.

The relationship between the city system and the development of manufacturing has become very apparent. The rapid growth and spread of cities within the heartland-hinterland framework after 1870 was conditioned to a large extent by industrial developments and that the decentralization of population within the urban system in recent years is related in large part to the movement of employment in manufacturing away from the traditional industrial centres. Manufacturing is found in nearly all cities, but its importance is measured by the proportion of total earnings received by the inhabitants of an urban area. When 25 percent or more of the total earnings in an urban region are derived from manufacturing, that urban areas is arbitrarily designated as a manufacturing centre.

The location of manufacturing is affected by myriad economic and non-economic factors, such as the nature of the material inputs, the factors of production, the market and transportation costs. Other important influences include agglomeration and external economies, public policy and personal preferences. Although it is difficult to evaluate precisely the effect of the market on the location of manufacturing activities, two considerations are involved: the nature of and demand for the product and transportation costs.

BEHAVIOURAL GEOGRAPHY

Behavioural geography is an approach to human geography that examines human behaviour using a disaggregate approach. Behavioural geographers focus on the cognitive processes underlying spatial reasoning, decision making, and behaviour.

In addition, behavioural geography is an ideology/approach in human geography that makes use of the methods and assumptions of behaviourism to determine the cognitive processes involved in an individual's perception of, and/or response and reaction to its environment.

Behavioural geography is that branch of human science, which deals with the study of cognitive processes with its response to its environment, through behaviourism.

Issues in Behavioural Geography

Because of the name it is often assumed to have its roots in behaviourism. While some behavioural geographers clearly have roots in behaviourism due to the emphasis on cognition, most can be seen as cognitively oriented. Indeed, it seems that behaviourism interest is more recent and growing This is particularly true in the area of human landscaping.

Behavioural geography is an approach to human geography that examines human behaviour using a disaggregate approach. It draws from early, behaviourist works such as Tolman's concepts of "cognitive maps". More cognitively oriented, behavioural geographers focus on the cognitive processes underlying spatial reasoning, decision making, and behaviour. More behaviourally oriented geographers are materialists and look at the role of basic learning processes and how they influence the lanscape patterns or even group identity.

The cognitive processes include environmental perception and cognition, way finding, the construction of cognitive maps, place attachment, the development of attitudes about space and place, decisions and behaviour based on imperfect knowledge of one's environs, and numerous other topics.

The approach adopted in behavioural geography is closely related to that of psychology, but draws on research findings from a multitude of other disciplines including economics, sociology, anthropology, transportation planning, and many others.

7

Climatology

CLIMATOLOGY

Climatology is the study of climate, scientifically defined as weather conditions averaged over a period of time, and is a branch of the atmospheric sciences. Basic knowledge of climate can be used within shorter term weather forecasting using analog techniques such as the El Nino-Southern Oscillation (ENSO), the Madden-Julian Oscillation (MJO), the North Atlantic Oscillation (NAO), the Northern Annualar Mode (NAM), the Arctic oscillation (AO), the Northern Pacific (NP) Index, the Pacific Decadal Oscillation (PDO), and the Interdecadal Pacific Oscillation (IPO). Climate models are used for a variety of purposes from study of the dynamics of the weather and climate system to projections of future climate.

History

The earliest person to hypothesize the concept of climate change may have been the medieval Chinese scientist Shen Kuo (1031-1095 AD). Shen Kuo theorized that climates naturally shifted over an enormous span of time, after observing petrified bamboos found underground near Yanzhou (modern day Yan'an, Shaanxi province), a dry climate area unsuitable for the growth of bamboo.

Early climate researchers include Edmund Halley, who published a map of the trade winds in 1686, after a voyage to the southern hemisphere. Benjamin Franklin, in the 18th century, was the first to map the course of the Gulf Stream for use in sending mail overseas from the United States to Europe.

Francis Galton invented the term *anticyclone*. Helmut Landsberg led to statistical analysis being used in climatology, which led to its evolution into a physical science.

Different Approaches

Climatology is approached in a variety of ways. Paleoclimatology seeks to reconstruct past climates by examining records such as ice cores and tree rings (dendroclimatology). Paleotempestology uses these same records to help determine hurricane frequency over millennia. The study of contemporary climates incorporates meteorological data accumulated over many years, such as records of rainfall, temperature and atmospheric composition. Knowledge of the atmosphere and its dynamics is also embodied in models, either statistical or mathematical, which help by integrating different observations and testing how they fit together. Modelling is used for understanding past, present and potential future climates. Historical climatology is the study of climate as related to human history and thus focuses only on the last few thousand years.

Climate research is made difficult by the large scale, long time periods, and complex processes which govern climate. Climate is governed by physical laws which can be expressed as differential equations. These equations are coupled and nonlinear, so that approximate solutions are obtained by using numerical methods to create global climate models. Climate is sometimes modelled as a stochastic process but this is generally accepted as an approximation to processes that are otherwise too complicated to analyze.

Indices

Scientists use climate indices based on several climate patterns (known as modes of variability) in their attempt to characterize and understand the various climate mechanisms that culminate in our daily weather. Much in the way the Dow Jones Industrial Average, which is based on the stock prices of 30 companies, is used to represent the fluctuations in the stock market as a whole, climate indices are used to represent the essential elements of climate.

Climate indices are generally devised with the twin objectives of simplicity and completeness, and each index typically represents the status and timing of the climate factor it represents. By their very nature, indices are simple, and combine many details into a generalized, overall description of the atmosphere or ocean which can be used to characterize the factors which impact the global climate system.

El Nino-Southern Oscillation

El Nino-Southern Oscillation (ENSO) is a global coupled ocean-atmosphere phenomenon. The Pacific ocean signatures, El Nino and La Niña are important temperature fluctuations in surface waters of the tropical Eastern Pacific Ocean. The name El Nino, from the Spanish for “the little boy”, refers to the Christ child, because the phenomenon is usually noticed around Christmas time in the Pacific Ocean off the west coast of South America. La Nina means “the little girl”. Their effect on climate in the subtropics and the tropics are profound. The atmospheric signature, the Southern Oscillation (SO) reflects the monthly or seasonal fluctuations in the air pressure difference between Tahiti and Darwin. The most recent occurrence of El Nino started in September 2006 and lasted until early 2007.

ENSO is a set of interacting parts of a single global system of coupled ocean-atmosphere climate fluctuations that come about as a consequence of oceanic and atmospheric circulation. ENSO is the most prominent known source of inter-annual variability in weather and climate around the world. The cycle occurs every two to seven years, with El Nino lasting nine months to two years within the longer term cycle, though not all areas globally are affected. ENSO has signatures in the Pacific, Atlantic and Indian Oceans. El Nino causes weather patterns which causes it to rain in specific places but not in others, this is one of many causes for the drought.

In the Pacific, during major warm events, El Nino warming extends over much of the tropical Pacific and becomes clearly linked to the SO intensity. While ENSO events are basically in phase between the Pacific and Indian Oceans, ENSO events in the Atlantic Ocean lag behind those in the Pacific by 12 to 18 months.

Many of the countries most affected by ENSO events are developing countries within tropical sections of continents with economies that are largely dependent upon their agricultural and fishery sectors as a major source of food supply, employment, and foreign exchange. New capabilities to predict the onset of ENSO events in the three oceans can have global socio-economic impacts. While ENSO is a global and natural part of the Earth's climate, whether its intensity or frequency may change as a result of global warming is an important concern. Low-frequency variability has been evidenced: the quasi-decadal oscillation (QDO). Inter-decadal (ID) modulation of ENSO (from PDO or IPO) might exist. This could explain the so-called protracted ENSO of the early 1990s.

Madden-Julian Oscillation

The Madden-Julian Oscillation (MJO) is an equatorial travelling pattern of anomalous rainfall that is planetary in scale. It is characterized by an eastward progression of large regions of both enhanced and suppressed tropical rainfall, observed mainly over the Indian Ocean and Pacific Ocean.

The anomalous rainfall is usually first evident over the western Indian Ocean, and remains evident as it propagates over the very warm ocean waters of the western and central tropical Pacific.

This pattern of tropical rainfall then generally becomes very nondescript as it moves over the cooler ocean waters of the eastern Pacific but reappears over the tropical Atlantic and Indian Ocean. The wet phase of enhanced convection and precipitation is followed by a dry phase where convection is suppressed. Each cycle lasts approximately 30–60 days. The MJO is also known as the 30-60 day oscillation, 30-60 day wave, or intraseasonal oscillation.

North Atlantic Oscillation (NAO)

Indices of the NAO are based on the difference of normalized sea level pressure (SLP) between Ponta Delgada, Azores and Stykkisholmur/Reykjavik, Iceland. The SLP anomalies at each station were normalized by division of each seasonal mean pressure by the long-term mean (1865-1984) standard deviation.

Normalization is done to avoid the series of being dominated by the greater variability of the northern of the two stations.

Positive values of the index indicate stronger-than-average westerlies over the middle latitudes.

Northern Annular Mode (NAM) or Arctic Oscillation (AO)

The NAM, or AO, is defined as the first EOF of northern hemisphere winter SLP data from the tropics and subtropics. It explains 23% of the average winter (December-March) variance, and it is dominated by the NAO structure in the Atlantic. Although there are some subtle differences from the regional pattern over the Atlantic and Arctic, the main difference is larger amplitude anomalies over the North Pacific of the same sign as those over the Atlantic. This feature gives the NAM a more annular (or zonally symmetric) structure.

Northern Pacific (NP) Index

The NP Index is the area-weighted sea level pressure over the region 30N-65N, 160E-140W.

Pacific Decadal Oscillation (PDO)

The PDO is a pattern of Pacific climate variability that shifts phases on at least inter-decadal time scale, usually about 20 to 30 years. The PDO is detected as warm or cool surface waters in the Pacific Ocean, north of 20°N. During a "warm", or "positive", phase, the west Pacific becomes cool and part of the eastern ocean warms; during a "cool" or "negative" phase, the opposite pattern occurs. The mechanism by which the pattern lasts over several years has not been identified; one suggestion is that a thin layer of warm water during summer may shield deeper cold waters. A PDO signal has been reconstructed to 1661 through tree-ring chronologies in the Baja California area.

Interdecadal Pacific Oscillation (IPO)

The Interdecadal Pacific Oscillation (IPO or ID) display similar sea surface temperature (SST) and sea level pressure patterns to the PDO, with a cycle of 15–30 years, but affects both the north and south Pacific. In the tropical Pacific, maximum SST anomalies are found away from the equator. This is quite different from the quasidecadal oscillation (QDO) with a period of 8-to-12 years and maximum SST anomalies straddling the equator, thus resembling ENSO.

Models

Climate models use quantitative methods to simulate the interactions of the atmosphere, oceans, land surface, and ice. They are used for a variety of purposes from study of the dynamics of the weather and climate system to projections of future climate. All climate models balance, or very nearly balance, incoming energy as short wave (including visible) electromagnetic radiation to the earth with outgoing energy as long wave (infrared) electromagnetic radiation from the earth. Any unbalance results in a change in the average temperature of the earth.

The most talked-about models of recent years have been those relating temperature to emissions of carbon dioxide. These models predict an upward trend in the surface temperature record, as well as a more rapid increase in temperature at higher altitudes.

Models can range from relatively simple to quite complex:

- A simple radiant heat transfer model that treats the earth as a single point and averages outgoing energy
- This can be expanded vertically (radiative-convective models), or horizontally
- Finally, (coupled) atmosphere–ocean–sea ice global climate models discretise and solve the full equations for mass and energy transfer and radiant exchange

Differences with Meteorology

In contrast to meteorology, which focuses on short term weather systems lasting up to a few weeks, climatology studies the frequency and trends of those systems. It studies the periodicity of weather events over years to millennia, as well as changes in long-term average weather patterns, in relation to atmospheric conditions. Climatologists, those who practice climatology, study both the nature of climates-local, regional or global-and the natural or human-induced factors that cause climates to change. Climatology considers the past and can help predict future climate change.

Phenomena of climatological interest include the atmospheric boundary layer, circulation patterns, heat transfer (radiative, convective and latent), interactions between the atmosphere and the oceans and land surface (particularly vegetation, land use and topography), and the chemical and physical composition of the atmosphere.

Use in Weather Forecasting

A more complicated way of making a forecast, the analog technique requires remembering a previous weather event which is expected to be mimicked by an upcoming event. What makes it a difficult technique to use is that there is rarely a perfect analog for an event in the future. Some call this type of forecasting pattern recognition, which remains a useful method of observing rainfall over data voids such as oceans with knowledge of how satellite imagery relates to precipitation rates over land, as well as the forecasting of precipitation amounts and distribution in the future. A variation on this theme is used in Medium Range forecasting, which is known as teleconnections, when you use systems in other locations to help pin down the location of another system within the surrounding regime. One method of using teleconnections are by using climate indices such as ENSO-related phenomena.

CLIMATE

Climates encompasses the statistics of temperature, humidity, atmospheric pressure, wind, rainfall, atmospheric particle count and other meteorological elements in a given region over long periods of time. Climate can be contrasted to weather, which is the present condition of these same elements and their variations over periods up to two weeks.

The climate of a location is affected by its latitude, terrain, and altitude, as well as nearby water bodies and their currents. Climates can be classified according to the average and the typical ranges of different variables, most commonly temperature and precipitation. The most commonly used classification scheme was originally developed by Wladimir Koppen.

The Thornthwaite system, in use since 1948, incorporates evapotranspiration in addition to temperature and precipitation information and is used in studying animal species diversity and potential impacts of climate changes. The Bergeron and Spatial Synoptic Classification systems focus on the origin of air masses that define the climate of a region. Paleoclimatology is the study of ancient climates. Since direct observations of climate are not available before the 19th century, paleoclimates are inferred from *proxy variables* that include non-biotic evidence such as sediments found in lake beds and ice cores, and biotic evidence such as tree rings and coral. Climate models are mathematical models of past, present and future climates.

Definition

Climate (from Ancient Greek *klima*, meaning *inclination*) is commonly defined as the weather averaged over a long period of time. The standard averaging period is 30 years, but other periods may be used depending on the purpose. Climate also includes statistics other than the average, such as the magnitudes of day-to-day or year-to-year variations. The Intergovernmental Panel on Climate Change (IPCC) glossary definition is:

Climate in a narrow sense is usually defined as the "average weather," or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period is 30 years, as defined by the World Meteorological Organization (WMO). These quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system.

The difference between climate and weather is usefully summarized by the popular phrase "Climate is what you expect, weather is what you get." Over historical time spans there are a number of nearly constant variables that determine climate, including latitude, altitude, proportion of land to water, and proximity to oceans and mountains. These change only over periods of millions of years due to processes such as plate tectonics.

Other climate determinants are more dynamic: for example, the thermohaline circulation of the ocean leads to a 5 °C (9 °F) warming of the northern Atlantic ocean compared to other ocean basins. Other ocean currents redistribute heat between land and water on a more regional scale. The density and type of vegetation coverage affects solar heat absorption, water retention, and rainfall on a regional level. Alterations in the quantity of atmospheric greenhouse gases determines the amount of solar energy retained by the planet, leading to global warming or global cooling. The variables which determine climate are numerous and the interactions complex, but there is general agreement that the broad outlines are understood, at least insofar as the determinants of historical climate change are concerned.

Climate Classification

There are several ways to classify climates into similar regimes. Originally, climes were defined in Ancient Greece to describe the weather depending upon a location's latitude. Modern climate classification methods can be broadly divided into *genetic* methods, which focus on the causes of climate, and *empiric* methods, which focus on the effects of climate. Examples of genetic classification include methods based on the relative frequency of different air mass types or locations within synoptic weather disturbances. Examples of empiric classifications include climate zones defined by plant hardiness, evapotranspiration, or more generally the Koppen climate classification which was originally designed to identify the climates associated with certain biomes. A common shortcoming of these classification schemes is that they produce distinct boundaries between the zones they define, rather than the gradual transition of climate properties more common in nature.

Bergeron and Spatial Synoptic

The most generic classification is that involving the concept of air masses. The Bergeron classification is the most widely accepted form of air mass classification. Air mass classification involves three letters. The first letter describes its moisture properties, with c used for continental air masses (dry) and m for maritime air masses (moist). The second letter describes the thermal characteristic of its source region: T for tropical, P for polar, A for Arctic or Antarctic, M for monsoon, E for equatorial, and S for superior air (dry air formed by significant downward motion in the atmosphere). The third letter is used to designate the stability of the atmosphere. If the air mass is colder than the ground below it, it is labelled k. If the air mass is warmer than the ground below it, it is labelled w. While air mass identification was originally used in weather forecasting during the 1950s, climatologists began to establish synoptic climatologies based on this idea in 1973.

Based upon the Bergeron classification scheme is the Spatial Synoptic Classification system (SSC). There are six categories within the SSC scheme: Dry Polar (similar to continental polar), Dry Moderate (similar to maritime superior), Dry Tropical (similar to continental tropical), Moist Polar (similar to maritime polar), Moist Moderate (a hybrid between maritime polar and maritime tropical), and Moist Tropical (similar to maritime tropical, maritime monsoon, or maritime equatorial).

Koppen

The Koppen classification depends on average monthly values of temperature and precipitation. The most commonly used form of the Koppen classification has five primary types labelled A through E. These primary types are A, tropical; B, dry; C, mild mid-latitude; D, cold mid-latitude; and E, polar. The five primary classifications can be further divided into secondary classifications such as rain forest, monsoon, tropical savanna, humid subtropical, humid continental, oceanic climate, Mediterranean climate, steppe, subarctic climate, tundra, polar ice cap, and desert.

Rain forests are characterized by high rainfall, with definitions setting minimum normal annual rainfall between 1,750 millimetres (69 in) and 2,000 millimetres (79 in). Mean monthly temperatures exceed 18 °C (64 °F) during all months of the year. A monsoon is a seasonal prevailing wind which lasts for several months, ushering in a region's rainy season. Regions within North America, South America, Sub-Saharan Africa, Australia and East Asia are monsoon regimes. A tropical savanna is a grassland biome located in semi-arid to semi-humid climate regions of subtropical and tropical latitudes, with average temperatures remain at or above 18 °C (64 °F) year round and rainfall between 750 millimetres (30 in) and 1,270 millimetres (50 in) a year. They are widespread on Africa, and are also found in India, the northern parts of South America, Malaysia, and Australia.

The humid subtropical climate zone where winter rainfall (and sometimes snowfall) is associated with large storms that the westerlies steer from west to east. Most summer rainfall occurs during thunderstorms and from occasional tropical cyclones. Humid subtropical climates lie on the east side continents, roughly between latitudes 20° and 40° degrees away from the equator.

A humid continental climate is marked by variable weather patterns and a large seasonal temperature variance. Places with more than three months of average daily temperatures above 10 °C (50 °F) and a coldest month temperature below “3 °C (26.6 °F) and which do not meet the criteria for an arid or semiarid climate, are classified as continental.

An oceanic climate is typically found along the west coasts at the middle latitudes of all the world's continents, and in southeastern Australia, and is accompanied by plentiful precipitation year round.

The Mediterranean climate regime resembles the climate of the lands in the Mediterranean Basin, parts of western North America, parts of Western and South Australia, in southwestern South Africa and in parts of central Chile. The climate is characterized by hot, dry summers and cool, wet winters.

A steppe is a dry grassland with an annual temperature range in the summer of up to 40 °C (104 °F) and during the winter down to “40 °C (“40.0 °F).

A subarctic climate has little precipitation, and monthly temperatures which are above 10 °C (50 °F) for one to three months of the year, with permafrost in large parts of the area due to the cold winters. Winters within subarctic climates usually include up to six months of temperatures averaging below 0 °C (32 °F).

A polar ice cap, or polar ice sheet, is a high-latitude region of a planet or moon that is covered in ice. Ice caps form because high-latitude regions receive less energy in the form of solar radiation from the sun than equatorial regions, resulting in lower surface temperatures.

A desert is a landscape form or region that receives very little precipitation. Deserts usually have a large diurnal and seasonal temperature range, with high daytime temperatures (in summer up to 45 °C or 113 °F), and low night-time temperatures (in winter down to 0 °C; 32 °F) due to extremely low humidity. Many deserts are formed by rain shadows, as mountains block the path of moisture and precipitation to the desert.

Thornthwaite

Devised by the American climatologist and geographer C. W. Thornthwaite, this climate classification method monitors the soil water budget using the concept of evapotranspiration. It monitors the portion of total precipitation used to nourish vegetation over a certain area. It uses indices such as a humidity index and an aridity index to determine an area's moisture regime based upon its average temperature, average rainfall, and average vegetation type. The lower the value of the index in any given area, the drier the area is.

The moisture classification includes climatic classes with descriptors such as hyperhumid, humid, subhumid, subarid, semi-arid (values of-20 to-40), and arid. Humid regions experience more precipitation than evaporation each year, while arid regions experience greater evaporation than precipitation on an annual basis. A total of 33 percent of the Earth's landmass is considered either arid of semi-arid, including southwest North America, southwest South America, most of northern and a small part of southern Africa, southwest and portions of eastern Asia, as well as much of Australia. Studies suggest that precipitation effectiveness (PE) within the Thornthwaite moisture index is overestimated in the summer and underestimated in the winter. This index can be effectively used to determine the number of herbivore and mammal species numbers within a given area. The index is also used in studies of climate change.

Thermal classifications within the Thornthwaite scheme include microthermal, mesothermal, and megathermal regimes. A microthermal climate is one of low annual mean temperatures, generally between 0 °C (32 °F) and 14 °C (57 °F) which experiences short summers and has a potential evaporation between 14 centimetres (5.5 in) and 43 centimetres (17 in). A mesothermal climate lacks persistent heat or persistent cold, with potential evaporation between 57 centimetres (22 in) and 114 centimetres (45 in). A megathermal climate is one with persistent high temperatures and abundant rainfall, with potential evaporation in excess of 114 centimetres (45 in).

Record

Modern: Details of the modern climate record are known through the taking of measurements from such weather instruments as thermometers, barometers, and anemometers during the past few centuries. The instruments used to study weather conditions over the modern time scale, their known error, their immediate environment, and their exposure have changed over the years, which must be considered when studying the climate of centuries past.

Paleoclimatology

Paleoclimatology is the study of past climate over a great period of the Earth's history. It uses evidence from ice sheets, tree rings, sediments, coral, and rocks to determine the past state of the climate. It demonstrates periods of stability and periods of change and can indicate whether changes follow patterns such as regular cycles.

Climate Change

Climate change is the variation in global or regional climates over time. It reflects changes in the variability or average state of the atmosphere over time scales ranging from decades to millions of years. These changes can be caused by processes internal to the Earth, external forces (e.g. variations in sunlight intensity) or, more recently, human activities.

In recent usage, especially in the context of environmental policy, the term "climate change" often refers only to changes in modern climate, including the rise in average surface temperature known as global warming. In some cases, the term is also used with a presumption of human causation, as in the United Nations Framework Convention on Climate Change (UNFCCC). The UNFCCC uses "climate variability" for non-human caused variations.

Earth has undergone periodic climate shifts in the past, including four major ice ages. These consisting of glacial periods where conditions are colder than normal, separated by interglacial periods. The accumulation of snow and ice during a glacial period increases the surface albedo, reflecting more of the Sun's energy into space and maintaining a lower atmospheric temperature. Increases in greenhouse gases, such as by volcanic activity, can increase the global temperature and produce an interglacial. Suggested causes of ice age periods include the positions of the continents, variations in the Earth's orbit, changes in the solar output, and vulcanism.

Climate Models

Climate models use quantitative methods to simulate the interactions of the atmosphere, oceans, land surface and ice. They are used for a variety of purposes from study of the dynamics of the weather and climate system to projections of future climate. All climate models balance, or very nearly balance, incoming energy as short wave (including visible) electromagnetic radiation to the earth with outgoing energy as long wave (infrared) electromagnetic radiation from the earth. Any imbalance results in a change in the average temperature of the earth.

The most talked-about models of recent years have been those used to infer the consequences of increasing greenhouse gases in the atmosphere, primarily carbon dioxide. These models predict an upward trend in the global mean surface temperature, with the most rapid increase in temperature being projected for the higher latitudes of the Northern Hemisphere.

Models can range from relatively simple to quite complex:

- Simple radiant heat transfer model that treats the earth as a single point and averages outgoing energy
- This can be expanded vertically (radiative-convective models), or horizontally
- Finally, (coupled) atmosphere–ocean–sea ice global climate models discretise and solve the full equations for mass and energy transfer and radiant exchange

CLIMATE CHANGE

Climate change is a change in the statistical distribution of weather over periods of time that range from decades to millions of years. It can be a change in the average weather or a change in the distribution of weather events around an average (for example, greater or fewer extreme weather events). Climate change may be limited to a specific region, or may occur across the whole Earth.In recent usage, especially in the context of environmental policy, climate change usually refers to changes in modern climate. It may be qualified as anthropogenic climate change, more generally known as "global warming" or "anthropogenic global warming" (AGW).

Terminology

The most general definition of *climate change* is a change in the statistical properties of the climate system when considered over periods of decades or longer, regardless of cause. Accordingly, fluctuations on periods shorter than a few decades, such as El Nino, do not represent climate change.

The term sometimes is used to refer specifically to climate change caused by human activity; for example, the United Nations Framework Convention on Climate Change defines climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods." In the latter sense climate change is synonymous with global warming.

Causes

Factors that can shape climate are climate forcings. These include such processes as variations in solar radiation, deviations in the Earth's orbit, mountain-building and continental drift, and changes in greenhouse gas concentrations. There are a variety of climate change feedbacks that can either amplify or diminish the initial forcing. Some parts of the climate system, such as the oceans and ice caps, respond slowly in reaction to climate forcing because of their large mass. Therefore, the climate system can take centuries or longer to fully respond to new external forcings.

Plate Tectonics

Over the course of millions of years, the motion of tectonic plates re-configures global land and ocean areas and generates topography. This can affect both global and local patterns of climate and atmosphere-ocean circulation.

The position of the continents determines the geometry of the oceans and therefore influences patterns of ocean circulation.

The locations of the seas are important in controlling the transfer of heat and moisture across the globe, and therefore, in determining global climate. A recent example of tectonic control on ocean circulation is the formation of the Isthmus of Panama about 5 million years ago, which shut off direct mixing between the Atlantic and Pacific Oceans. This strongly affected the ocean dynamics of what is now the Gulf Stream and may have led to Northern Hemisphere ice cover. During the Carboniferous period, about 300 to 360 million years ago, plate tectonics may have triggered large-scale storage of carbon and increased glaciation. Geologic evidence points to a "megamonsoonal" circulation pattern during the time of the supercontinent Pangaea, and climate modelling suggests that the existence of the supercontinent was conducive to the establishment of monsoons.

The size of continents is also important. Because of the stabilizing effect of the oceans on temperature, yearly temperature variations are generally lower in coastal areas than they are inland. A larger supercontinent will therefore have more area in which climate is strongly seasonal than will several smaller continents or islands.

Solar Output

The sun is the predominant source for energy input to the Earth. Both long-and short-term variations in solar intensity are known to affect global climate.

Three to four billion years ago the sun emitted only 70% as much power as it does today. If the atmospheric composition had been the same as today, liquid water should not have existed on Earth. However, there is evidence for the presence of water on the early Earth, in the Hadean and Archean eons, leading to what is known as the faint young sun paradox. Hypothesized solutions to this paradox include a vastly different atmosphere, with much higher concentrations of greenhouse gases than currently exist Over the following approximately 4 billion years, the energy output of the sun increased and atmospheric composition changed, with the oxygenation of the atmosphere around 2.4 billion years ago being the most notable alteration. These changes in luminosity, and the sun's ultimate death as it becomes a red giant and then a white dwarf, will have large effects on climate, with the red giant phase possibly ending life on Earth.

Solar output also varies on shorter time scales, including the 11-year solar cycle and longer-term modulations. Solar intensity variations are considered to have been influential in triggering the Little Ice Age, and some of the warming observed from 1900 to 1950. The cyclical nature of the sun's energy output is not yet fully understood; it differs from the very slow change that is happening within the sun as it ages and evolves. While most research indicates solar variability has induced a small cooling effect from 1750 to the present, a few studies point toward solar radiation increases from cyclical sunspot activity affecting global warming.

Orbital Variations

Slight variations in Earth's orbit lead to changes in the seasonal distribution of sunlight reaching the Earth's surface and how it is distributed across the globe. There is very little change to the area-averaged annually averaged sunshine; but there can be strong changes in the geographical and seasonal distribution. The three types of orbital variations are variations in Earth's eccentricity, changes in the tilt angle of Earth's axis of rotation, and precession of Earth's axis. Combined together, these produce Milankovitch cycles which have a large impact on climate and are notable for their correlation to glacial and interglacial periods, their correlation with the advance and retreat of the Sahara, and for their appearance in the stratigraphic record.

Gradual Push, Sudden Shift

During a gradual push, things sometimes tip, slip, and break. Had the 1997 El Nioo lasted twice as long, the rain forests of the Amazon basin and Southeast Asia could have quickly added much additional carbon dioxide to the air from burning and rotting, with heat waves and extreme weather quickly felt around the world (The "Burn locally, crash globally" scenario).

Most abrupt climate shifts, however, are likely due to sudden circulation shifts. The best-known examples are the several dozen shutdowns of the North Atlantic Ocean's Meridional

Overturning Circulation during the last ice age, affecting climate worldwide. But there have been a series of less dramatic abrupt climate shifts since 1976, along with some near misses.

The circulation shift in the western Pacific in the winter of 1976-1977 proved to have much wider impacts. Since 1950, El Nioos had been weak and short, but La Nioas were often big and long, This pattern reversed after 1977. Land temperatures had remained relatively trendless from 1950 to 1976, despite the CO_2 rising from 310 to 332 ppm as fossil fuel emissions tripled. Then in 1977 there was a marked shift in observed global-mean surface temperature to a rising fever on land at about 2°C/century.

The expansion of the tropics from overheating is usually thought to be gradual, but the percentage of the land surface in the two most extreme classifications of drought suddenly doubled in 1982 and stayed there until 1997 when it jumped to triple (after six years, it stepped down to double). While their inception correlates with the particularly large El Ninos of 1982 and 1997, the global drought steps far outlast the 13-month durations of those El Ninos.

In addition to near-misses for Burn Locally, Crash Globally in 1998, 2005, and 2007, there have also been two occasions when the Atlantic's Meridional Overturning Circulation lost a crucial safety factor. The Greenland Sea flushing at 75□°N shut down in 1978, recovering over the next decade. While shutdowns overlapping in time have not been seen during the fifty years of observation, previous total shutdowns had severe worldwide climate consequences.This makes abrupt climate shifts more like a heart attack than like a chronic disease whose course can be extrapolated. Some abrupt climate shifts are minor, some are catastrophic—and one cannot predict which or when. In the recent past, there have been at least several sudden shifts and several near-misses per decade.

Volcanism

Volcanism is a process of conveying material from the crust and mantle of the Earth to its surface. Volcanic eruptions, geysers, and hot springs, are examples of volcanic processes which release gases and/or particulates into the atmosphere.

Eruptions large enough to affect climate occur on average several times percentury, and cause cooling (by partially blocking the transmission of solar radiation to the Earth's surface) for a period of a few years. The eruption of Mount Pinatubo in 1991, the second largest terrestrial eruption of the 20th century (after the 1912 eruption of Novarupta) affected the climate substantially. Global temperatures decreased by about 0.5 °C (0.9 °F). The eruption of Mount Tambora in 1815 caused the Year Without a Summer. Much larger eruptions, known as large igneous provinces, occur only a few times every hundred million years, but may cause global warming and mass extinctions.

Volcanoes are also part of the extended carbon cycle. Over very long (geological) time periods, they release carbon dioxide from the Earth's crust and mantle, counteracting the uptake by sedimentary rocks and other geological carbon dioxide sinks. According to the US Geological Survey, however, estimates are that human activities generate more than 130 times the amount of carbon dioxide emitted by volcanoes.

Ocean Variability

The ocean is a fundamental part of the climate system. Short-term fluctuations (years to a few decades) such as the El Nino–Southern Oscillation, the Pacific decadal oscillation, the North Atlantic oscillation, and the Arctic oscillation, represent climate variability rather than climate change. On longer time scales, alterations to ocean processes such as thermohaline circulation play a key role in redistributing heat by carrying out a very slow and extremely deep movement of water, and the long-term redistribution of heat in the world's oceans.

Human Influences

Anthropogenic factors are human activities that change the environment. In some cases the chain of causality of human influence on the climate is direct and unambiguous (for example, the effects of irrigation on local humidity), while in other instances it is less clear. Various hypotheses for human-induced climate change have been argued for many years. Presently the scientific consensus on climate change is that human activity is very likely the cause for the rapid increase in global average temperatures over the past several decades. Consequently, the debate has largely shifted onto ways to reduce further human impact and to find ways to adapt to change that has already occurred.

Of most concern in these anthropogenic factors is the increase in CO_2 levels due to emissions from fossil fuel combustion, followed by aerosols (particulate matter in the atmosphere) and cement manufacture. Other factors, including land use, ozone depletion, animal agriculture and deforestation, are also of concern in the roles they play-both separately and in conjunction with other factors-in affecting climate, microclimate, and measures of climate variables.

ATMOSPHERE

An atmosphere is a layer of gases that may surround a material body of sufficient mass, by the gravity of the body, and are retained for a longer duration if gravity is high and the atmosphere's temperature is low. Some planets consist mainly of various gases, but only their outer layer is their atmosphere.

The term stellar atmosphere describes the outer region of a star, and typically includes the portion starting from the opaque photosphere outwards. Relatively low-temperature stars may form compound molecules in their outer atmosphere. Earth's atmosphere, which contains oxygen used by most organisms for respiration and carbon dioxide used by plants, algae and cyanobacteria for photosynthesis, also protects living organisms from genetic damage by solar ultraviolet radiation. Its current composition is the product of billions of years of biochemical modification of the paleoatmosphere by living organisms.

Pressure

Atmospheric pressure is the force per unit area that is applied perpendicularly to a surface by the surrounding gas. It is determined by a planet's gravitational force in combination with the total mass of a column of air above a location. Units of air pressure are based on the internationally-recognized standard atmosphere (atm), which is defined as 101,325 Pa (or 1,013,250 dynes per cm^2).

The pressure of an atmospheric gas decreases with altitude due to the diminishing mass of gas above each location. The height at which the pressure from an atmosphere declines by a factor of *e* (an irrational number with a value of 2.71828..) is called the scale height and is denoted by *H*. For an atmosphere with a uniform temperature, the scale height is proportional to the temperature and inversely proportional to the mean molecular mass of dry air times the planet's gravitational acceleration. For such a model atmosphere, the pressure declines exponentially with increasing altitude. However, atmospheres are not uniform in temperature, so the exact determination of the atmospheric pressure at any particular altitude is more complex.

Escape

Surface gravity, the force that holds down an atmosphere, differs significantly among the planets. For example, the large gravitational force of the giant planet Jupiter is able to retain light gases such as hydrogen and helium that escape from lower gravity objects. Second, the distance from the sun determines the energy available to heat atmospheric gas to the point where its molecules' thermal motion exceed the planet's escape velocity, the speed at which gas molecules overcome a planet's gravitational grasp.

Thus, the distant and cold Titan, Triton, and Pluto are able to retain their atmospheres despite relatively low gravities. Interstellar planets, theoretically, may also retain thick atmospheres.

Since a gas at any particular temperature will have molecules moving at a wide range of velocities, there will almost always be some slow leakage of gas into space. Lighter molecules move faster than heavier ones with the same thermal kinetic energy, and so gases of low molecular weight are lost more rapidly than those of high molecular weight. It is thought that Venus and Mars may have both lost much of their water when, after being photodissociated into hydrogen and oxygen by solar ultraviolet, the hydrogen escaped. Earth's magnetic field helps to prevent this, as, normally, the solar wind would greatly enhance the escape of hydrogen. However, over the past 3 billion years the Earth may have lost gases through the magnetic polar regions due to auroral activity, including a net 2% of its atmospheric oxygen. Other mechanisms that can cause atmosphere depletion are solar wind-induced sputtering, impact erosion, weathering, and sequestration — sometimes referred to as “freezing out” — into the regolith and polar caps.

Composition

Initial atmospheric makeup is generally related to the chemistry and temperature of the local solar nebula during planetary formation and the subsequent escape of interior gases. These original atmospheres underwent much evolution over time, with the varying properties of each planet resulting in very different outcomes. The atmospheres of the planets Venus and Mars are primarily composed of carbon dioxide, with small quantities of nitrogen, argon, oxygen and traces of other gases.

The atmospheric composition on Earth is largely governed by the by-products of the very life that it sustains. Earth’s atmosphere contains roughly (by molar content/volume) 78.09% nitrogen, 20.95% oxygen, a variable amount (average around 0.247%, National Centre for Atmospheric Research) water vapor, 0.93% argon, 0.038% carbon dioxide, and traces of hydrogen, helium, and other “noble” gases. The low temperatures and higher gravity of the gas giants — Jupiter, Saturn, Uranus and Neptune — allows them to more readily retain gases with low molecular masses. These planets have hydrogen-helium atmospheres, with trace amounts of more complex compounds.

Two satellites of the outer planets possess non-negligible atmospheres: Titan, a moon of Saturn, and Triton, a moon of Neptune, which are mainly nitrogen. Pluto, in the nearer part of its orbit, has an atmosphere of nitrogen and methane similar to Triton’s, but these gases are frozen when farther from the Sun. Other bodies within the Solar System have extremely thin atmospheres not in equilibrium. These include the Moon (sodium gas), Mercury (sodium gas), Europa (oxygen), Io (sulfur), and Enceladus (water vapor).

The atmospheric composition of an extra-solar planet was first determined using the Hubble Space Telescope. Planet HD 209458b is a gas giant with a close orbit around a star in the constellation Pegasus. The atmosphere is heated to temperatures over 1,000 K, and is steadily escaping into space. Hydrogen, oxygen, carbon and sulfur have been detected in the planet’s inflated atmosphere.

Structure

Earth: The Earth's atmosphere consists, from the ground up, of the troposphere (which includes the planetary boundary layer or peplosphere as lowest layer), stratosphere (which includes the ozone layer), mesosphere, thermosphere (which contains the ionosphere), exosphere and also the magnetosphere. Each of the layers has a different lapse rate, defining the rate of change in temperature with height.

Three quarters of the atmosphere lies within the troposphere, and the depth of this layer varies between 17 km at the equator and 7 km at the poles. The ozone layer, which absorbs ultraviolet energy from the Sun, is located primarily in the stratosphere, at altitudes of 15 to 35 km. The Karman line, located within the thermosphere at an altitude of 100 km, is commonly used to define the boundary between the Earth's atmosphere and outer space. However, the exosphere can extend from 500 up to 10,000 km above the surface, where it interacts with the planet's magnetosphere.

Circulation: The circulation of the atmosphere occurs due to thermal differences when convection becomes a more efficient transporter of heat than thermal radiation. On planets where the primary heat source is solar radiation, excess heat in the tropics is transported to higher latitudes. When a planet generates a significant amount of heat internally, such as is the case for Jupiter, convection in the atmosphere can transport thermal energy from the higher temperature interior up to the surface.

Importance

From the perspective of the planetary geologist, the atmosphere is an evolutionary agent essential to the morphology of a planet. The wind transports dust and other particles which erodes the relief and leaves deposits (eolian processes). Frost and precipitations, which depend on the composition, also influence the relief. Climate changes can influence a planet's geological history. Conversely, studying surface of earth leads to an understanding of the atmosphere and climate of a planet-both its present state and its past.

For a meteorologist, the composition of the atmosphere determines the climate and its variations.

For a biologist, the composition is closely dependent on the appearance of the life and its evolution.

SOLAR CONSTANT

The solar constant, a measure of flux, is the amount of incoming solar electromagnetic radiation per unit area that would be incident on a plane perpendicular to the rays, at a distance of one astronomical unit (AU) (roughly the mean distance from the Sun to the Earth). When solar irradiance is measured on the outer surface of Earth's atmosphere, the measurements can be adjusted using the inverse square law to infer the magnitude of solar irradiance at one AU and deduce the solar constant.

The solar constant includes all types of solar radiation, not just the visible light. It is measured by satellite to be roughly 1.366 kilowatts per square meter (kW/m^2). The actual direct solar irradiance at the top of the atmosphere fluctuates by about 6.9% during a year (from 1.412 kW/m^2 in early January to 1.321 kW/m^2 in early July) due to the Earth's varying distance from the Sun, and typically by much less than one part per thousand from day to day. Thus, for the whole Earth (which has a cross section of 127,400,000 km^2), the power is 1.740×10 W, plus or minus 3.5%. The solar constant does not remain constant over long periods of time, but over a year varies much less than the variation of direct solar irradiance at the top of the atmosphere arising from the ellipticity of the Earth's orbit. The approximate average value cited, 1.366 kW/m^2, is equivalent to 1.96 calories per minute per square centimetre, or 1.96 langleys (Ly) per minute.

The Earth receives a total amount of radiation determined by its cross section, but as it rotates this energy is distributed across the entire surface area. Hence the average incoming solar radiation, taking into account the angle at which the rays strike and that at any one moment half the planet does not receive any solar radiation, is one-fourth the solar constant (approximately 342 W/m^2). At any given moment, the amount of solar radiation received at a location on the Earth's surface depends on the state of the atmosphere and the location's latitude. The solar constant includes all wavelengths of solar electromagnetic radiation, not just the visible light. It is linked to the apparent magnitude of the Sun, “26.8, in that the solar constant and the magnitude of the Sun are two methods of describing the apparent brightness of the Sun, though the magnitude is based on the Sun’s visual output only.

In 1884, Samuel Pierpont Langley attempted to estimate the solar constant from Mount Whitney in California. By taking readings at different times of day, he attempted to remove effects due to atmospheric absorption. However, the value he obtained, 2.903□kW/m^2, was still too great. Between 1902 and 1957, measurements by Charles Greeley Abbot and others at various high-altitude sites found values between 1.322 and 1.465□kW/m^2. Abbott proved that one of Langley’s corrections was erroneously applied. His results varied between 1.89 and 2.22 calories (1.318 to 1.548□□kW/m^2), a variation that appeared to be due to the Sun and not the Earth’s atmosphere.

The angular diameter of the Earth as seen from the Sun is approximately 1/11,700 radians (about 18 arc-seconds), meaning the solid angle of the Earth as seen from the Sun is approximately 1/175,000,000 of a steradian. Thus the Sun emits about 2.2 billion times the amount of radiation that is caught by Earth, in other words about 3.86×10 watts.

Sunlight Intensity in the Solar System

Different bodies of the Solar System receive light of an intensity inversely proportional to the square of their distance from Sun. A rough table comparing the amount of light received by each planet on the Solar System follows:

Planet	***Perihelion-Aphelion distance (AU)***	***Solar Radiation maximum and Minimum(W/m²)***
Mercury	0.3075 – 0.4667	14,446 – 6,272
Venus	0.7184 – 0.7282	2,647 – 2,576
Earth	0.9833 – 1.017	1,413 – 1,321
Mars	1.382 – 1.666	715 – 492
Jupiter	4.950 – 5.458	55.8 – 45.9
Saturn	9.048 – 10.12	16.7 – 13.4
Uranus	18.38 – 20.08	4.04 – 3.39
Neptune	29.77 – 30.44	1.54 – 1.47

The actual brightness of sunlight that would be observed at the surface depends also on the presence and composition of an atmosphere. For example Venus' thick atmosphere reflects more than 60% of the solar light it receives. The actual illumination of the surface is about 14,000 lux, comparable to that on Earth "in the daytime with overcast clouds".

Sunlight on Mars would be more or less like daylight on Earth wearing sunglasses, and as can be seen in the pictures taken by the rovers, there is enough diffuse sky radiation that shadows would not seem particularly dark. Thus it would give perceptions and "feel" very much like Earth daylight. For comparison purposes, sunlight on Saturn is slightly brighter than Earth sunlight at the average sunset or sunrise. Even on Pluto the sunlight would still be bright enough to almost match the average living room. To see sunlight as dim as full moonlight on the Earth, a distance of about 500 AU (~69 light-hours) is needed; there is only a handful of objects in the solar system known to orbit farther than such a distance, among them 90377 Sedna and (87269) 2000 OO67.

Composition

The spectrum of the Sun's solar radiation is close to that of a black body with a temperature of about 5,800 K. About half that lies in the visible short-wave part of the electromagnetic spectrum and the other half mostly in the near-infrared part. Some also lies in the ultraviolet part of the spectrum. When ultraviolet radiation is not absorbed by the atmosphere or other protective coating, it can cause damage to the skin known as sunburn or trigger an adaptive change in human skin pigmentation. The spectrum of electromagnetic radiation striking the Earth's atmosphere is 100 to 10^6 nanometers (nm). This can be divided into five regions in increasing order of wavelengths:

- Ultraviolet C or (UVC) range, which spans a range of 100 to 280 nm. The term *ultraviolet* refers to the fact that the radiation is at higher frequency than violet light (and, hence also invisible to the human eye). Owing to absorption by the atmosphere very little reaches the Earth's surface (Lithosphere). This spectrum of radiation has germicidal properties, and is used in germicidal lamps.
- Ultraviolet B or (UVB) range spans 280 to 315 nm. It

is also greatly absorbed by the atmosphere, and along with UVC is responsible for the photochemical reaction leading to the production of the Ozone layer.

- Ultraviolet A or (UVA) spans 315 to 400 nm. It has been traditionally held as less damaging to the DNA, and hence used in tanning and PUVA therapy for psoriasis.
- Visible range or light spans 400 to 700 nm. As the name suggests, it is this range that is visible to the naked eye.
- Infrared range that spans 700 nm to 10^6 nm [1 (mm)]. It is responsible for an important part of the electromagnetic radiation that reaches the Earth. It is also divided into three types on the basis of wavelength:
  - Infrared-A: 700 nm to 1,400 nm.
  - Infrared-B: 1,400 nm to 3,000 nm.
  - Infrared-C: 3,000 nm to 1 mm.

Surface Illumination

The spectrum of surface illumination depends upon solar elevation due to atmospheric effects, with the blue spectral component from atmospheric scatter dominating during twilight before and after sunrise and sunset, respectively, and red dominating during sunrise and sunset.

These effects are apparent in natural light photography where the principal source of illumination is sunlight as mediated by the atmosphere.

According to Craig Bohren, “preferential absorption of sunlight by ozone over long horizon paths gives the zenith sky its blueness when the sun is near the horizon”.

Climate Effects

On Earth, solar radiation is obvious as daylight when the sun is above the horizon. This is during daytime, and also in summer near the poles at night, but not at all in winter near the poles. When the direct radiation is not blocked by clouds, it is experienced as *sunshine*, combining the perception of bright white light (sunlight in the strict sense) and warming. The warming on the body, the ground and other objects depends on the absorption (electromagnetic radiation) of the electromagnetic radiation in the form of heat.

Life on Earth

The existence of nearly all life on Earth is fuelled by light from the sun. Most autotrophs, such as plants, use the energy of sunlight, combined with minerals and air, to produce simple sugars—a process known as photosynthesis. These sugars are then used as building blocks and in other synthetic pathways which allow the organism to grow. Heterotrophs, such as animals, use light from the sun indirectly by consuming the products of autotrophs, either directly or by consuming other heterotrophs.

The sugars and other molecular components produced by the autotrophs are then broken down, releasing stored solar energy, and giving the heterotroph the energy required for survival. This process is known as respiration.

In prehistory, humans began to further extend this process by putting plant and animal materials to other uses. They used animal skins for warmth, for example, or wooden weapons to hunt. These skills allowed humans to harvest more of the sunlight than was possible through glycolysis alone, and human population began to grow. During the Neolithic Revolution, the domestication of plants and animals further increased human access to solar energy. Fields devoted to crops were enriched by inedible plant matter, providing sugars and nutrients for future harvests. Animals which had previously only provided humans with meat and tools once they were killed were now used for labour throughout their lives, fuelled by grasses inedible to humans.

The more recent discoveries of coal, petroleum and natural gas are modern extensions of this trend. These fossil fuels are the remnants of ancient plant and animal matter, formed using energy from sunlight and then trapped within the earth for millions of years. Because the stored energy in these fossil fuels has accumulated over many millions of years, they have allowed modern humans to massively increase the production and consumption of primary energy. As the amount of fossil fuel is large but finite, this cannot continue indefinitely, and various theories exist as to what will follow this stage of human civilization (e.g. alternative fuels, Malthusian catastrophe, new urbanism, peak oil).

Cultural Aspects

Many people find direct sunlight to be too bright for comfort, especially when reading from white paper upon which the sun is directly shining. Indeed, looking directly at the sun can cause long-term vision damage.

To compensate for the brightness of sunlight, many people wear sunglasses. Cars, many helmets and caps are equipped with visors to block the sun from direct vision when the sun is at a low angle.

In colder countries, many people prefer sunnier days and often avoid the shade. In hotter countries the converse is true; during the midday hours many people prefer to stay inside to remain cool. If they do go outside, they seek shade which may be provided by trees, parasols, and so on. Sunshine is often blocked from entering buildings through the use of walls, window blinds, awnings, shutters or curtains.

Sunbathing

Sunbathing is a popular leisure activity in which a person sits or lies in direct sunshine. People often sunbathe in comfortable places where there is ample sunlight. Some common places for sunbathing include beaches, open air swimming pools, parks, gardens, and sidewalk cafes. Sunbathers typically wear limited amounts of clothing or some simply go nude. An alternative some use to sunbathing is to use a sunbed that generates ultraviolet light and can be used indoors regardless of outdoor weather conditions and amount of sun light.

For many people with pale or brownish skin, one purpose for sunbathing is to darken one's skin colour (get a sun tan) as this is considered in some cultures to be beautiful, associated with outdoor activity, vacations/holidays, and health. Some people prefer nude sunbathing so that an "all-over" or "even" tan can be obtained.

Skin tanning is achieved by an increase in the dark pigment inside skin cells called melanocytes and it is actually an automatic response mechanism of the body to sufficient exposure to ultraviolet radiation from the sun or from artificial sunlamps. Thus, the tan gradually disappears with time, when one is no longer exposed to these sources.

Effects on Human Health

The body produces vitamin D from sunlight (specifically from the UVB band of ultraviolet light), and excessive seclusion from the sun can lead to deficiency unless adequate amounts are obtained through diet. This very common deficiency leaves the body generally vulnerable to cancers.

On the other hand, excessive sunlight exposure has been linked to all types of skin cancer caused by the ultraviolet part of radiation from sunlight or sunlamps. Sunburn can have mild to severe inflammation effects on skin; this can be avoided by using a proper sunscreen cream or lotion or by gradually building up melanocytes with increasing exposure. Another detrimental effect of UV exposure is accelerated skin aging (also called skin photodamage), which produces a difficult to treat cosmetic effect. Some people are concerned that ozone depletion is increasing the incidence of such health hazards. A 10% decrease in ozone could cause a 25% increase in skin cancer.

A lack of sunlight, on the other hand, is considered one of the primary causes of seasonal affective disorder (SAD), a serious form of the “winter blues”. SAD occurrence is more prevalent in locations further from the tropics, and most of the treatments (other than prescription drugs) involve light therapy, replicating sunlight via lamps tuned to specific (visible, not ultra-violet) wavelengths of light or full-spectrum bulbs.

A recent study indicates that more exposure to sunshine early in a person’s life relates to less risk from multiple sclerosis (MS) later in life.

8

Geographical Water Resources

Water resources are sources of water that are useful or potentially useful to humans. Uses of water include agricultural, industrial, household, recreational and environmental activities. Virtually all of these human uses require fresh water. 97% of water on the Earth is salt water, leaving only 3% as fresh water of which slightly over two thirds is frozen in glaciers and polar ice caps. The remaining unfrozen freshwater is mainly found as groundwater, with only a small fraction present above ground or in the air. Fresh water is a renewable resource, yet the world's supply of clean, fresh water is steadily decreasing. Water demand already exceeds supply in many parts of the world and as the world population continues to rise, so too does the water demand. Awareness of the global importance of preserving water for ecosystem services has only recently emerged as, during the 20th century, more than half the world's wetlands have been lost along with their valuable environmental services. Biodiversity-rich freshwater ecosystems are currently declining faster than marine or land ecosystems. The framework for allocating water resources to water users (where such a framework exists) is known as water rights.

SOURCES OF FRESH WATER

Surface Water

Surface water is water in a river, lake or fresh water wetland. Surface water is naturally replenished by precipitation and naturally lost through discharge to the oceans, evaporation, and sub-surface seepage. Although the only natural input to any surface water system is precipitation within its watershed, the total quantity of water in that system at any given time is also dependent on many other factors. These factors include storage capacity in lakes, wetlands and artificial reservoirs, the permeability of the soil beneath these storage bodies, the runoff characteristics of the land in the watershed, the timing of the precipitation and local evaporation rates. All of these factors also affect the proportions of water lost.

Human activities can have a large and sometimes devastating impact on these factors. Humans often increase storage capacity by constructing reservoirs and decrease it by draining wetlands. Humans often increase runoff quantities and velocities by paving areas and channelizing stream flow. The total quantity of water available at any given time is an important consideration. Some human water users have an intermittent need for water. For example, many farms require large quantities of water in the spring, and no water at all in the winter. To supply such a farm with water, a surface water system may require a large storage capacity to collect water throughout the year and release it in a short period of time. Other users have a continuous need for water, such as a power plant that requires water for cooling. To supply such a power plant with water, a surface water system only needs enough storage capacity to fill in when average stream flow is below the power plant's need.

Nevertheless, over the long term the average rate of precipitation within a watershed is the upper bound for average consumption of natural surface water from that watershed. Natural surface water can be augmented by importing surface water from another watershed through a canal or pipeline. It can also be artificially augmented from any of the other sources listed here, however in practice the quantities are negligible. Humans can also cause surface water to be "lost" (i.e. become unusable) through pollution. Brazil is the country estimated to have the largest supply of fresh water in the world, followed by Russia and Canada.

Under River Flow

Throughout the course of the river, the total volume of water transported downstream will often be a combination of the visible free water flow together with a substantial contribution flowing through sub-surface rocks and gravels that underlie the river and its floodplain called the hyporheic zone. For many rivers in large valleys, this unseen component of flow may greatly exceed the visible flow. The hyporheic zone often forms a dynamic interface between surface water and true ground-water receiving water from the ground water when aquifers are fully charged and contributing water to ground-water when ground waters are depleted. This is especially significant in karst areas where pot-holes and underground rivers are common.

Groundwater

Sub-surface water, or groundwater, is fresh water located in the pore space of soil and rocks. It is also water that is flowing within aquifers below the water table. Sometimes it is useful to make a distinction between sub-surface water that is closely associated with surface water and deep sub-surface water in an aquifer (sometimes called "fossil water"). Sub-surface water can be thought of in the same terms as surface water: inputs, outputs and storage. The critical difference is that due to its slow rate of turnover, sub-surface water storage is generally much larger compared to inputs than it is for surface water. This difference makes it easy for humans to use sub-surface water unsustainably for a long time without severe consequences. The natural input to sub-surface water is seepage from surface water. The natural outputs from sub-surface water are springs and seepage to the oceans. If the surface water source is also subject to substantial evaporation, a sub-surface water source may become saline. This situation can occur naturally under endorheic bodies of water, or artificially under irrigated farmland. In coastal areas, human use of a sub-surface water source may cause the direction of seepage to ocean to reverse which can also cause soil salinization. Humans can also cause sub-surface water to be "lost" (i.e. become unusable) through pollution. Humans can increase the input to a sub-surface water source by building reservoirs or detention ponds.

Desalination

Desalination is an artificial process by which saline water (generally sea water) is converted to fresh water. The most common desalination processes are distillation and reverse osmosis. Desalination is currently expensive compared to most alternative sources of water, and only a very small fraction of total human use is satisfied by desalination. It is only economically practical for high-valued uses (such as household and industrial uses) in arid areas. The most extensive use is in the Persian Gulf.

Frozen Water

Several schemes have been proposed to make use of icebergs as a water source, however to date this has only been done for novelty purposes. Glacier runoff is considered to be surface water.

The Himalayas, which are often called "The Roof of the World", contain some of the most extensive and rough high altitude areas on Earth as well as the greatest area of glaciers and permafrost outside of the poles. Ten of Asia's largest rivers flow from there, and more than a billion people's livelihoods depend on them. To complicate matters, temperatures are rising more rapidly here than the global average. In Nepal the temperature has risen with 0.6 degree over the last decade, whereas the global warming has been around 0.7 over the last hundred years.

USES OF FRESH WATER

Uses of fresh water can be categorized as consumptive and non-consumptive (sometimes called "renewable"). A use of water is consumptive if that water is not immediately available for another use. Losses to sub-surface seepage and evaporation are considered consumptive, as is water incorporated into a product (such as farm produce). Water that can be treated and returned as surface water, such as sewage, is generally considered non-consumptive if that water can be put to additional use.

Agricultural

It is estimated that 69% of worldwide water use is for irrigation, with 15-35% of irrigation withdrawals being unsustainable. In some areas of the world irrigation is necessary to grow any crop at all, in other areas it permits more profitable crops to be grown or enhances crop yield. Various irrigation methods involve different trade-offs between crop yield, water consumption and capital cost of equipment and structures. Irrigation methods such as furrow and overhead sprinkler irrigation are usually less expensive but are also typically less efficient, because much of the water evaporates, runs off or drains below the root zone. Other irrigation methods considered to be more efficient include drip or trickle irrigation, surge irrigation, and some types of sprinkler systems where the sprinklers are operated near ground level. These types of systems, while more expensive, usually offer greater potential to minimize runoff, drainage and evaporation. Any system that is improperly managed can be wasteful, all methods have the potential for high efficiencies under suitable conditions, appropriate irrigation timing and management. One issue that is often insufficiently considered is salinization of sub-surface water.

Aquaculture is a small but growing agricultural use of water. Freshwater commercial fisheries may also be considered as agricultural uses of water, but have generally been assigned a lower priority than irrigation.

As global populations grow, and as demand for food increases in a world with a fixed water supply, there are efforts underway to learn how to produce more food with less water, through improvements in irrigation methods and technologies, agricultural water management, crop types, and water monitoring.

Industrial

It is estimated that 22% of worldwide water use is industrial. Major industrial users include power plants, which use water for cooling or as a power source (i.e. hydroelectric plants), ore and oil refineries, which use water in chemical processes, and manufacturing plants, which use water as a solvent. The portion of industrial water usage that is consumptive varies widely, but as a whole is lower than agricultural use. Water is used in power generation. Hydroelectricity is electricity obtained from hydropower. Hydroelectric power comes from water driving a water turbine connected to a generator. Hydroelectricity is a low-cost, non-polluting, renewable energy source. The energy is supplied by the sun. Heat from the sun evaporates water, which condenses as rain in higher altitudes, from where it flows down.

Pressurized water is used in water blasting and water jet cutters. Also, very high pressure water guns are used for precise cutting. It works very well, is relatively safe, and is not harmful to the environment. It is also used in the cooling of machinery to prevent over-heating, or prevent saw blades from over-heating.

Water is also used in many industrial processes and machines, such as the steam turbine and heat exchanger, in addition to its use as a chemical solvent. Discharge of untreated water from industrial uses is pollution. Pollution includes discharged solutes (chemical pollution) and discharged coolant water (thermal pollution). Industry requires pure water for many applications and utilizes a variety of purification techniques both in water supply and discharge.

Household

It is estimated that 8% of worldwide water use is for household purposes. These include drinking water, bathing, cooking, sanitation, and gardening. Basic household water requirements have been estimated by Peter Gleick at around 50 litres per person per day, excluding water for gardens. Drinking water is water that is of sufficiently high quality so that it can be consumed or used without risk of immediate or long term harm. Such water is commonly called potable water. In most developed countries, the water supplied to households, commerce and industry is all of drinking water standard even though only a very small proportion is actually consumed or used in food preparation.

Recreation

Recreational water use is usually a very small but growing percentage of total water use. Recreational water use is mostly tied to reservoirs. If a reservoir is kept fuller than it would otherwise be for recreation, then the water retained could be categorized as recreational usage. Release of water from a few reservoirs is also timed to enhance whitewater boating, which also could be considered a recreational usage. Other examples are anglers, water skiers, nature enthusiasts and swimmers. Recreational usage is usually non-consumptive. Golf courses are often targeted as using excessive amounts of water, especially in drier regions. It is, however, unclear whether recreational irrigation (which would include private gardens) has a noticeable effect on water resources. This is largely due to the unavailability of reliable data. Additionally, many golf courses utilize either primarily or exclusively treated effluent water, which has little impact on potable water availability. Some governments, including the Californian Government, have labelled golf course usage as agricultural in order to deflect environmentalists' charges of wasting water. However, using the above figures as a basis, the actual statistical effect of this reassignment is close to zero. In Arizona, an organized lobby has been established in the form of the Golf Industry Association, a group focused on educating the public on how golf impacts the environment.

Recreational usage may reduce the availability of water for other users at specific times and places. For example, water retained in a reservoir to allow boating in the late summer is not available to farmers during the spring planting season. Water released for whitewater rafting may not be available for hydroelectric generation during the time of peak electrical demand.

Environmental

Explicit environmental water use is also a very small but growing percentage of total water use. Environmental water usage includes artificial wetlands, artificial lakes intended to create wildlife habitat, fish ladders, and water releases from reservoirs timed to help fish spawn.

Like recreational usage, environmental usage is non-consumptive but may reduce the availability of water for other users at specific times and places. For example, water release from a reservoir to help fish spawn may not be available to farms upstream.

WATER STRESS

The concept of water stress is relatively simple: According to the World Business Council for Sustainable Development, it applies to situations where there is not enough water for all uses, whether agricultural, industrial or domestic. Defining thresholds for stress in terms of available water per capita is more complex, however, entailing assumptions about water use and its efficiency.

Nevertheless, it has been proposed that when annual per capita renewable freshwater availability is less than 1,700 cubic meters, countries begin to experience periodic or regular water stress. Below 1,000 cubic meters, water scarcity begins to hamper economic development and human health and well-being.

Population Growth

In 2000, the world population was 6.2 billion. The UN estimates that by 2050 there will be an additional 3.5 billion people with most of the growth in developing countries that already suffer water stress. Thus, water demand will increase unless there are corresponding increases in water conservation and recycling of this vital resource.

Expansion of Business Activity

Business activity ranging from industrialization to services such as tourism and entertainment continues to expand rapidly. This expansion requires increased water services including both supply and sanitation, which can lead to more pressure on water resources and natural ecosystems.

Rapid Urbanization

The trend towards urbanization is accelerating. Small private wells and septic tanks that work well in low-density communities are not feasible within high-density urban areas. Urbanization requires significant investment in water infrastructure in order to deliver water to individuals and to process the concentrations of wastewater – both from individuals and from business.

These polluted and contaminated waters must be treated or they pose unacceptable public health risks. In 60% of European cities with more than 100,000 people, groundwater is being used at a faster rate than it can be replenished. Even if some water remains available, it costs more and more to capture it.

Climate Change

Climate change could have significant impacts on water resources around the world because of the close connections between the climate and hydrological cycle. Rising temperatures will increase evaporation and lead to increases in precipitation, though there will be regional variations in rainfall. Overall, the global supply of freshwater will increase. Both droughts and floods may become more frequent in different regions at different times, and dramatic changes in snowfall and snowmelt are expected in mountainous areas. Higher temperatures will also affect water quality in ways that are not well understood. Possible impacts include increased eutrophication. Climate change could also mean an increase in demand for farm irrigation, garden sprinklers, and perhaps even swimming pools.

Depletion of Aquifers

Due to the expanding human population, competition for water is growing such that many of the worlds major aquifers are becoming depleted. This is due both for direct human consumption as well as agricultural irrigation by groundwater. Millions of pumps of all sizes are currently extracting groundwater throughout the world. Irrigation in dry areas such as northern China and India is supplied by groundwater, and is being extracted at an unsustainable rate. Cities that have experienced aquifer drops between 10 to 50 meters include Mexico City, Bangkok, Manila, Beijing, Madras and Shanghai.

Pollution and Water Protection

Water pollution is one of the main concerns of the world today. The governments of many countries have striven to find solutions to reduce this problem. Many pollutants threaten water supplies, but the most widespread, especially in underdeveloped countries, is the discharge of raw sewage into natural waters; this method of sewage disposal is the most common method in underdeveloped countries, but also is prevalent in quasi-developed countries such as China, India and Iran. Sewage, sludge, garbage, and even toxic pollutants are all dumped into the water. Even if sewage is treated, problems still arise. Treated sewage forms sludge, which may be placed in landfills, spread out on land, incinerated or dumped at sea. In addition to sewage, nonpoint source pollution such as agricultural runoff is a significant source of pollution in some parts of the world, along with urban stormwater runoff and chemical wastes dumped by industries and governments.

Water and Conflict

The only known example of an actual interstate conflict over water took place between 2500 and 2350 BC between the Sumerian states of Lagash and Umma. Yet, despite the lack of evidence of international wars being fought over water alone, water has been the source of various conflicts throughout history. When water scarcity causes political tensions to arise, this is referred to as water stress. Water stress has led most often to conflicts at local and regional levels.

Using a purely quantitative methodology, Thomas Homer-Dixon successfully correlated water scarcity and scarcity of available arable lands to an increased chance of violent conflict. Water stress can also exacerbate conflicts and political tensions which are not directly caused by water. Gradual reductions over time in the quality and/or quantity of fresh water can add to the instability of a region by depleting the health of a population, obstructing economic development, and exacerbating larger conflicts.

Conflicts and tensions over water are most likely to arise within national borders, in the downstream areas of distressed river basins. Areas such as the lower regions of China's Yellow River or the Chao Phraya River in Thailand, for example, have already been experiencing water stress for several years. Additionally, certain arid countries which rely heavily on water for irrigation, such as China, India, Iran, and Pakistan, are particularly at risk of water-related conflicts. Political tensions, civil protest, and violence may also occur in reaction to water privatization. The Bolivian Water Wars of 2000 are a case in point.

WORLD WATER SUPPLY AND DISTRIBUTION

Food and water are two basic human needs. However, global coverage figures from 2002 indicate that, of every 10 people:

- Roughly 5 have a connection to a piped water supply at home (in their dwelling, plot or yard);

- 3 make use of some other sort of improved water supply, such as a protected well or public standpipe;
- 2 are unserved;
- In addition, 4 out of every 10 people live without improved sanitation.

At Earth Summit 2002 governments approved a Plan of Action to:

- Halve by 2015 the proportion of people unable to reach or afford safe drinking water. The Global Water Supply and Sanitation Assessment 2000 Report (GWSSAR) defines “Reasonable access” to water as at least 20 litres per person per day from a source within one kilometre of the user’s home;
- Halve the proportion of people without access to basic sanitation. The GWSSR defines “Basic sanitation” as private or shared but not public disposal systems that separate waste from human contact.

As the picture shows, in 2025, water shortages will be more prevalent among poorer countries where resources are limited and population growth is rapid, such as the Middle East, Africa, and parts of Asia. By 2025, large urban and peri-urban areas will require new infrastructure to provide safe water and adequate sanitation. This suggests growing conflicts with agricultural water users, who currently consume the majority of the water used by humans.

Generally speaking the more developed countries of North America, Europe and Russia will not see a serious threat to water supply by the year 2025, not only because of their relative wealth, but more importantly their populations will be better aligned with available water resources. North Africa, the Middle East, South Africa and northern China will face very severe water shortages due to physical scarcity and a condition of overpopulation relative to their carrying capacity with respect to water supply.

Most of South America, Sub-Saharan Africa, Southern China and India will face water supply shortages by 2025; for these latter regions the causes of scarcity will be economic constraints to developing safe drinking water, as well as excessive population growth.

1.6 billion people have gained access to a safe water source since 1990. The proportion of people in developing countries with access to safe water is calculated to have improved from 30 percent in 1970 to 71 percent in 1990, 79 percent in 2000 and 84 percent in 2004. This trend is projected to continue.

ECONOMIC CONSIDERATIONS

Water supply and sanitation require a huge amount of capital investment in infrastructure such as pipe networks, pumping stations and water treatment works. It is estimated that Organisation for Economic Co-operation and Development (OECD) nations need to invest at least USD 200 billion per year to replace aging water infrastructure to guarantee supply, reduce leakage rates and protect water quality. International attention has focused upon the needs of the developing countries. To meet the Millennium Development Goals targets of halving the proportion of the population lacking access to safe drinking water and basic sanitation by 2015, current annual investment on the order of USD 10 to USD 15 billion would need to be roughly doubled. This does not include investments required for the maintenance of existing infrastructure.

Once infrastructure is in place, operating water supply and sanitation systems entails significant ongoing costs to cover personnel, energy, chemicals, maintenance and other expenses. The sources of money to meet these capital and operational costs are essentially either user fees, public funds or some combination of the two. But this is where the economics of water management start to become extremely complex as they intersect with social and broader economic policy. Such policy questions are beyond the scope of this article, which has concentrated on basic information about water availability and water use. They are, nevertheless, highly relevant to understanding how critical water issues will affect business and industry in terms of both risks and opportunities.

OCEAN

An ocean is a major body of saline water, and a principal component of the hydrosphere. Approximately 71% of the Earth's surface (~3.61×10^{14} m^2) is covered by ocean, a continuous body of water that is customarily divided into several principal oceans and smaller seas. More than half of this area is over 3,000 metres (9,800 ft) deep. Average oceanic salinity is around 35 parts per thousand (ppt) (3.5%), and nearly all seawater has a salinity in the range of 30 to 38 ppt. Scientists estimate that 230,000 marine life forms of all types are currently known, but the total could be up to 10 times that number.

Overview

Though generally described as several ‘separate’ oceans, these waters comprise one global, interconnected body of salt water sometimes referred to as the World Ocean or global ocean. This concept of a continuous body of water with relatively free interchange among its parts is of fundamental importance to oceanography.

The major oceanic divisions are defined in part by the continents, various archipelagos, and other criteria. These divisions are (in descending order of size):

- Pacific Ocean, which separates Asia and Australia from the Americas
- Atlantic Ocean, which separates the Americas from Eurasia and Africa
- Indian Ocean, which washes upon southern Asia and separates Africa and Australia
- Southern Ocean, which, unlike other oceans, has no landmass separating it from other oceans and is therefore sometimes subsumed as the southern portions of the Pacific, Atlantic, and Indian Oceans, which encircles Antarctica and covers much of the Antarctic
- Arctic Ocean, sometimes considered a sea of the Atlantic, which covers much of the Arctic and washes upon northern North America and Eurasia

The Pacific and Atlantic may be further subdivided by the equator into northern and southern portions. Smaller regions of the oceans are called seas, gulfs, bays, straits and other names.

Geologically, an ocean is an area of oceanic crust covered by water. Oceanic crust is the thin layer of solidified volcanic basalt that covers the Earth’s mantle. Continental crust is thicker but less dense. From this perspective, the earth has three oceans: the World Ocean, the Caspian Sea, and Black

Sea. The latter two were formed by the collision of Cimmeria with Laurasia. The Mediterranean Sea is at times a discrete ocean, because tectonic plate movement has repeatedly broken its connection to the World Ocean through the Strait of Gibraltar.

The Black Sea is connected to the Mediterranean through the Bosporus, but the Bosporus is a natural canal cut through continental rock some 7,000 years ago, rather than a piece of oceanic sea floor like the Strait of Gibraltar. Despite their names, smaller landlocked bodies of saltwater that are *not* connected with the World Ocean, such as the Aral Sea, are actually salt lakes.

Ocean and Life

The ocean has a significant effect on the biosphere. Oceanic evaporation, as a phase of the water cycle, is the source of most rainfall, and ocean temperatures determine climate and wind patterns that affect life on land. Life within the ocean evolved 3 billion years prior to life on land. Both the depth and distance from shore strongly influence the amount and kinds of plants and animals that live there.

Physical Properties

The area of the World Ocean is 361×10^3 km^2 (139×10^6 mi^2) Its volume is approximately 1.3 billion cubic kilometres (310 million cu mi). This can be thought of as a cube of water with an edge length of 1,111 kilometres (690 mi). Its average depth is 3,790 metres (12,430 ft), and its maximum depth is 10,923 metres (6.787 mi) Nearly half of the world's marine waters are over 3,000 metres (9,800 ft) deep. The vast expanses of deep ocean (anything below 200 metres (660 ft) cover about 66% of the Earth's surface. This does not include seas not connected to the World Ocean, such as the Caspian Sea. The total mass of the hydrosphere is about 1,400,000,000,000,000,000 metric tons (1.5×10^{18} short tons) or 1.4×10^{21} kg, which is about 0.023 percent of the Earth's total mass. Less than 3 percent is freshwater; the rest is saltwater, mostly in the ocean.

Colour

A common misconception is that the oceans are blue primarily because the sky is blue. In fact, water has a very slight blue colour that can only be seen in large volumes. While the sky's reflection does contribute to the blue appearance of the surface, it is not the primary cause. The primary cause is the absorption by the water molecules' nuclei of red photons from the incoming light, the only known example of colour in nature resulting from vibrational, rather than electronic, dynamics.

Glow

Sailors and other mariners have reported that the ocean often emits a visible glow, or luminescence, which extends for miles at night. In 2005, scientists announced that for the first time, they had obtained photographic evidence of this glow. It may be caused by bioluminescence.

Exploration

Ocean travel by boat dates back to prehistoric times, but only in modern times has extensive underwater travel become possible. The deepest point in the ocean is the Mariana Trench, located in the Pacific Ocean near the Northern Mariana Islands. Its maximum depth has been estimated to be 10,971 metres (35,994 ft) (plus or minus 11 meters; see the Mariana Trench article for discussion of the various estimates of the maximum depth.) The British naval vessel, *Challenger II* surveyed the trench in 1951 and named the deepest part of the trench, the "Challenger Deep". In 1960, the Trieste successfully reached the bottom of the trench, manned by a crew of two men.

Much of the ocean bottom remains unexplored and unmapped. A global image of many underwater features larger than 10 kilometres (6.2 mi) was created in 1995 based on gravitational distortions of the nearby sea surface.

Regions and Depths

Oceanographers divide the ocean into regions depending on physical and biological conditions of these areas. The pelagic zone includes all open ocean regions, and can be divided into further regions categorized by depth and light abundance. The photic zone covers the oceans from surface level to 200 metres down. This is the region where photosynthesis can occur and therefore is the most biodiverse. Since plants require photosynthesis, life found deeper than this must either rely on material sinking from above or find another energy source; hydrothermal vents are the primary option in what is known as the aphotic zone (depths exceeding 200 m). The pelagic part of the photic zone is known as the epipelagic. The pelagic part of the aphotic zone can be further divided into regions that succeed each other vertically according to temperature.

The mesopelagic is the uppermost region. Its lowermost boundary is at a thermocline of 12 °C (54 °F), which, in the tropics generally lies at 700–1,000 metres (2,300–3,300 ft). Next is the bathypelagic lying between 10-4 °C (43 °F), typically between 700–1,000 metres (2,300–3,300 ft) and 2,000–4,000 metres (6,600–13,000 ft) Lying along the top of the abyssal plain is the abyssalpelagic, whose lower boundary lies at about 6,000 metres (20,000 ft). The last zone includes the deep trenches, and is known as the hadalpelagic. This lies between 6,000–11,000 metres (20,000–36,000 ft) and is the deepest oceanic zone. Along with pelagic aphotic zones there are also benthic aphotic zones. These correspond to the three deepest zones of the deep-sea. The bathyal zone covers the continental slope down to about 4,000 metres (13,000 ft). The abyssal zone covers the abyssal plains between 4,000 and 6,000 m. Lastly, the hadal zone corresponds to the hadalpelagic zone which is found in the oceanic trenches. The pelagic zone can also be split into two subregions, the neritic zone and the oceanic zone. The neritic encompasses the water mass directly above the continental shelves, while the oceanic zone includes all the completely open water. In contrast, the littoral zone covers the region between low and high tide and represents the transitional area between marine and terrestrial conditions. It is also known as the intertidal zone because it is the area where tide level affects the conditions of the region.

Geology

The ocean floor spreads from mid-ocean ridges where two plates adjoin. Where two plates move towards each other, one plate subducts under another plate (oceanic or continental) leading to an oceanic trench.

Climate Effects

Ocean currents greatly affect the Earth's climate by transferring heat from the tropics to the polar regions, and transferring warm or cold air and precipitation to coastal regions, where winds may carry them inland. Surface heat and freshwater fluxes create global density gradients that drive the thermohaline circulation part of large-scale ocean circulation. It plays an important role in supplying heat to the polar regions, and thus in sea ice regulation. Changes in the thermohaline circulation are thought to have significant impacts on the Earth's radiation budget. Insofar as the thermohaline circulation governs the rate at which deep waters reach the surface, it may also significantly influence atmospheric carbon dioxide concentrations.

For a discussion of the possibilities of changes to the thermohaline circulation under global warming, see shutdown of thermohaline circulation.

It is often stated that the thermohaline circulation is the primary reason that the climate Western Europe is so temperate. An alternate hypothesis claims that this is largely incorrect, and that Europe is warm mostly because it lies downwind of an ocean basin, and because atmospheric waves bring warm air north from the subtropics.

The Antarctic Circumpolar Current encircles that continent, influencing the area's climate and connecting currents in several oceans.

One of the most dramatic forms of weather occurs over the oceans: tropical cyclones (also called "typhoons" and "hurricanes" depending upon where the system forms).

Biology

Lifeforms native to oceans include:

- Radiata
- Fish
- Cetacea such as whales, dolphins and porpoises,
- Cephalopods such as octopus and squid
- Crustaceans such as lobsters, clams, shrimp and krill
- Marine worms
- Plankton
- Echinoderms such as brittle stars, starfish, sea cucumbers and sand dollars

Economy

The oceans are essential to transportation: most of the world's goods move by ship between the world's seaports. Oceans are also the major supply source for the fishing industry. Some of the more major these are shrimp, fish, crabs and lobster.

Continental drift continually re-configures the oceans, joining and splitting bodies of water. Ancient oceans include:

- Bridge River Ocean, the ocean between the ancient Insular Islands and North America.
- Iapetus Ocean, the southern hemisphere ocean between Baltica and Avalonia.
- Panthalassa, the vast world ocean that surrounded the Pangaea supercontinent.
- Rheic Ocean.
- Slide Mountain Ocean, the ocean between the ancient Intermontane Islands and North America.
- Tethys Ocean, the ocean between the ancient continents of Gondwana and Laurasia.
- Khanty Ocean, the ocean between Baltica and Siberia.
- Mirovia, the ocean that surrounded the Rodinia supercontinent.
- Paleo-Tethys Ocean, the ocean between Gondwana and the Hunic terranes.
- Poseidon Ocean.
- Proto-Tethys Ocean.
- Pan-African Ocean, the ocean that surrounded the Pannotia supercontinent.
- Superocean, the ocean that surrounds a global supercontinent.
- Ural Ocean, the ocean between Siberia and Baltica.

Extraterrestrial Oceans

Earth is the only known planet with liquid water on its surface and is certainly the only one in our own solar system. However, liquid water is thought to be present under the surface of the Galilean moons Europa and, with less certainty, Callisto and Ganymede. Geysers have been found on Saturn's moon Enceladus, though these may not involve bodies of liquid water. Other icy moons may have once had internal oceans that have now frozen, such as Triton. The planets Uranus and Neptune may also possess large oceans of liquid water under their thick atmospheres, though their internal structure is not well understood.

There is currently much debate over whether Mars once had an ocean in its northern hemisphere, and over what happened to it; recent findings by the Mars Exploration Rover mission indicate Mars had long-term standing water in at least one location, but its extent is not known. Astronomers believe that Venus had liquid water and perhaps oceans in its very early history. If they existed, all later vanished via resurfacing.

Liquid hydrocarbons are thought to be present on the surface of Titan, though *lakes* may be a more accurate term. The Cassini-Huygens space mission initially discovered only what appeared to be dry lakebeds and empty river channels, suggesting that Titan had lost what surface liquids it might have had. Cassini's more recent fly-by of Titan offers radar images that strongly suggest hydrocarbon lakes near the colder polar regions. Titan is thought to have a subterranean water ocean under the ice and hydrocarbon mix that forms its outer crust. Beyond the solar system, the planet Gliese 581 c is at the right distance from its sun to support liquid surface water. However, its greenhouse effect would make it too hot for oceans to exist on the surface.

On Gliese 581 d the greenhouse effect may bring temperatures suitable for surface oceans. Astronomers dispute whether HD 209458 b has water vapour in its atmosphere. Gliese 436 b is believed to have "hot ice." Neither of these planets are cool enough for liquid water—but if water molecules exist there, they are also likely to be found on planets at a suitable temperature. GJ 1214 b, detected by transit, found evidence that this planet has oceans made of exotic form of ice VII, making up 75% of all the planet's mass.

Ocean temperature and motion fields can be separated into 3 distinct layers: 1) mixed (surface) layer, 2) upper ocean (above the thermocline), and 3) deep ocean.

The mixed layer is nearest to the surface and can vary in thickness from 10 to 500 meters. This layer has properties such as temperature, salinity and dissolved Oxygen which are uniform with depth reflecting a history of active turbulence (the atmosphere has an analogous planetary boundary layer). Turbulence is really high in the mixed layer. However, it becomes zero at the base of the mixed layer.

Turbulence again increases below the base of the mixed layer due to shear instabilities. At extratropical latitudes this layer is deepest in late winter as a result of surface cooling and winter storms and quite shallow in summer. Its dynamics is governed by turbulent mixing as well as Ekman pumping, exchanges with the overlying atmosphere, and horizontal advection.

The upper ocean, characterized by warm temperatures and active motion, varies in depth from 100m or less in the tropics and eastern oceans to in excess of 800 meters in the western subtropical oceans. This layer exchanges properties such as heat and freshwater with the atmosphere on timescales of a few years. Below the mixed layer the upper ocean is generally governed by the hydrostatic and geostrophic relationships. Exceptions include the deep tropics and coastal regions.

The deep ocean is both cold and dark with generally weak velocities (although limited areas of the deep ocean are known to have significant recirculations). The deep ocean is supplied with water from the upper ocean in only a few limited geographical regions: the subpolar North Atlantic and several sinking regions around the Antarctic Because of the weak supply of water to the deep ocean the average residence time of water in the deep ocean is measured in hundreds of years. In this layer as well the hydrostatic and geostrophic relationships are generally valid and mixing is generally quite weak.

Mixed Layer Dynamics

Mixed layer dynamics are quite complicated, however is some regions some simplifications are possible. The wind-driven horizontal transport in the mixed layer is approximately described by Ekman Layer dynamics in which vertical diffusion of momentum balances the Coriolis effect and wind stress. This Ekman transport is superimposed on geostrophic flow associated with horizontal gradients of density.

Upper Ocean Dynamics

Horizontal convergences and divergences within the mixed layer due, for example, to Ekman transport convergence imposes a requirement that ocean below the mixed layer must move fluid particles vertically. But one of the implications of the geostrophic relationship is that the magnitude of horizontal motion must greatly exceed the magnitude of vertical motion. Thus the weak vertical velocities associated with Ekman transport convergence (measured in meters per day) cause horizontal motion with speeds of 10 centimetres per second or more. The mathematical relationship between vertical and horizontal velocities can be derived by expressing the idea of conservation of angular momentum for a fluid on a rotating sphere.

This relationship (with a couple of additional approximations) is known to oceanographers as the Sverdrup relation. Among its implications is the result that the horizontal convergence of Ekman transport observed to occur in the subtropical North Atlantic and Pacific forces southward flow throughout the interior of these two oceans. Western boundary currents (the Gulf Stream and Kuroshio) exist in order to return water to higher latitude.

Highland Climates

The major highland regions of the world (the Cascades, Sierra Nevada, and Rockies of North America, the Andes of South America, the Himalayas and adjacent ranges and the Tibetan Highlands [or Plateau] of Asia, the eastern highlands of Africa, and the central portions of Borneo and New Guinea) cannot be classified realistically at this scale of consideration, since the effects of altitude and relief give rise to myriad mesoclimates and microclimates. This diversity over short horizontal distances is inappable at the continental scale. Very little of a universal nature can be written about such mountain areas except to note that, as a rough approximation, they tend to resemble cooler, wetter versions of the climates of nearby lowlands in terms of their annual temperature ranges and seasonality of precipitation.

Tropical Highlands are of particular interest in that they can produce the whole gamut of climates on earth—the bottom of a mountain that is located on the equator would probably have tropical rainforest type climate. However, as you went up the mountain, you would pass through every climate regime, just as if you were increasing latitude by travelling north or south from the equator. If the mountain was high enough, a polar-style climate would be at the top—indeed, there are many snow-capped mountains in the tropical regions of the world.

Here is a general breakdown of the changing climate and environment of a tropical highland:

- 0-3000 feet above sea level; hot lands
- 3000-6500 feet; moderate temperate zones with intensive agriculture: coffee, tea, corn
- 6500-12000 feet; cool to cold with hardier crops like corn, wheat, potatoes, barley
- 12,000-15,000 feet approaching tundra and arctic like climate; some cattle, sheep, and limited forestry
- above 15,000 feet not unlike polar zone, permanent snow/ice cover

Arctic and Alpine Tundra

Tundra means marshy plain. The geographical distribution of the tundra biome is largely poleward of 60 degrees North latitude. The tundra biome is characterized by an absence of trees, the presence of dwarf plants, and a ground surface that is wet, spongy, and hummocky. Soils of this biome are usually permanently frozen (permafrost) starting at a depth of a few centimetres to meter or more. The permafrost line is a physical barrier to plant root growth. Within this biome, temperature, precipitation, and evaporation all tend to be at a minimum. Most tundra locations, have summer months with an average temperature below 10 degrees Celsius. Precipitation in the wettest month is normally no higher that 25 millimetres. However, despite the low levels of precipitation the ground surface of the tundra biome is often waterlogged because of low rates of evapotranspiration.

The species diversity of tundra vegetation is relatively small. Plant communities are usually composed of a few species of dwarf shrubs, a few grass species, sedges, and mosses.

Perhaps the most characteristic arctic tundra plants are lichens like Reindeer Moss. The principal herbivores in this biome include caribou, musk ox, arctic hare, voles, and lemmings. Most of the bird species of the tundra have the ability to migrate and live warmer locations during the cold winter months. The herbivore species support a small number of carnivore species like the arctic fox, snow owl, polar bear, and wolves. Reptiles and amphibians are few or completely absent because of the extremely cold temperatures. Alpine tundra is quite similar to some arctic tundra but differs in the absence of permafrost and in the presence of better drainage.

Tundra Climate

Tundra climates occur between 60º and 75º of latitude, mostly along the Arctic coast of North America and Eurasia and on the coastal margins of Greenland. Mean annual temperatures are below freezing and annual ranges are large. Summers are generally mild, with daily maxima from 15º to 18º C, although the mean temperature of the warmest month must be less than 10º C. Days are long (a result of the high latitude), but they are often cloudy.

The snow cover of winter melts in the warmer season; however, frosts and snow are possible in any month. Winters are long and cold (temperatures may be below 0º C for six to 10 months), especially in the region north of the Arctic Circle where, for at least one day in the year, the Sun does not rise. The latter regions also exhibit warmer winters, even in areas where the sea freezes.

Subarctic Climate

North of the humid continental climate, from about 50º to 70º N, in a broad swath extending from Alaska to Newfoundland in North America and from northern Scandinavia to Siberia in Eurasia, lie the continental subarctic climates. These are regions dominated by the winter season, a long, bitterly cold period with short, clear days, relatively little precipitation (mostly in the form of snow), and low humidity. In Asia the Siberian anticyclone, the source of continental polar air, dominates the interior, and mean temperatures 40º-50º C below freezing are not unusual. The North American representative of this climate is not as severe but is still profoundly cold.

Mean monthly temperatures are below freezing for six to eight months, with an average frost-free period of only 50-90 days per year, and snow remains on the ground for many months. Summers are short and mild, with long days and a prevalence of frontal precipitation associated with maritime tropical air within travelling cyclones. As a result of these temperature extremes, annual temperature ranges are larger in continental subarctic climates than in any other climate type on Earth, up to 30º C through much of the area and more than 60º C in central Siberia, although coastal areas are more moderate. Annual precipitation totals are mostly less than 50 centimetres, with a concentration in the summer. Higher totals, however, occur in marine areas near warm ocean currents. Such areas also are generally somewhat more equable and may be designated marine subarctic climates. The climate of this biome is cool to cold with more precipitation than the tundra, occurring mainly in the summer because of mid-latitude cyclones.

The predominant vegetation of boreal biome are needle leaf evergreen variety tree species. The understory is relatively limited as a result of the low light penetration even during the spring and fall months. Understory plants in the deciduous biome take advantage of the leafless condition of trees during these seasons concentrating there growth during this time period. Common understory species include orchids, shrubs like rose, blueberry, and cranberry.

Mammals common to the boreal forest include moose, bear, deer, wolverine, marten, lynx, wolf, snowshoe hare, vole, chipmunks, shrews, and bats. Reptiles are rare, once again, because of cold temperatures.

Subarctics Breakdown:

- Great extremes in seasonal temperatures
- Summers short and mild; winters long and severe
- Seasonal day/night length radical
- Precipitation generally low due to cold air masses inability to hold moisture
- However, low rate of evapotransporation equate to bog and pond formation
- Covered by vast deciduous forests= boreal forests= taiga

- Lower tree growth rate= smaller size, also lower plant/ animal diversity

Snow and Ice Climate

This climate occurs poleward of 65º N and S latitude over the ice caps of Greenland and Antarctica and over the permanently frozen portion of the Arctic Ocean, the source regions for arctic air masses. Temperatures are below freezing throughout the year, and annual temperature ranges are large, but again not as large as in the continental subarctic climates. Winters are frigid, with mean monthly temperatures from-20º C to-65º C; the lowest temperatures occur at the end of the long polar night. This climate holds the distinction for the lowest recorded temperatures at the Earth's surface: the Vostok II research station in Antarctica holds the record for the lowest extreme temperature (-89º C), while the Plateau Station has the lowest annual mean (-56º C).

Daily temperature variations are very small, because at such high latitudes the Sun's elevation varies little over the daylight period. Precipitation is meager in the cold, stable air (in most cases, five to 50 centimetres), with the largest amounts occurring on the coastal margins. Most of this precipitation results from the periodic penetration of a cyclone into the region, which brings snow and ice pellets and, with strong winds, blizzards. High winds also occur in the outer portions of the Greenland and Antarctic climates, where cold, dense air drains off the higher, central sections of the ice caps.

CLIMATE AND WATER RESOURCES

The vast majority of the Earth's water resources are salt water, with only 2.5% being fresh water. Approximately 70% of the fresh water available on the planet is frozen in the icecaps of Antarctica and Greenland leaving the remaining 30% (equal to only 0.7% of total water resources worldwide) available for consumption. From this remaining 0.7%, roughly 87% is allocated to agricultural purposes (IPCC 2007).

These statistics are particularly illustrative of the drastic problem of water scarcity facing the world. Water scarcity is defined as per capita supplies less than 1700 m3/year (IPCC 2007).

According to the Comprehensive Assessment of Water Management in Agriculture, one in three people are already facing water shortages (2007). Around 1.2 billion people, or almost one-fifth of the world's population, live in areas of physical scarcity, while another 1.6 billion people, or almost one quarter of the world's population, live in a developing country that lacks the necessary infrastructure to take water from rivers and aquifers (known as an economic water shortage).

There are four main factors aggravating water scarcity according to the IPCC:

- Population growth: in the last century, world population has tripled. It is expected to rise from the present 6.5 billion to 8.9 billion by 2050. Water use has been growing at more than twice the rate of population increase in the last century, and, although there is no global water scarcity as such, an increasing number of regions are chronically short of water.
- Increased urbanization will focus on the demand for water among a more concentrated population. Asian cities alone are expected to grow by 1 billion people in the next 20 years.
- High level of consumption: as the world becomes more developed, the amount of domestic water used by each person is expected to rise significantly.
- Climate change will shrink the resources of freshwater.

WATER AND CLIMATE CHANGE

Water scarcity is expected to become an ever-increasing problem in the future, for various reasons. First, the distribution of precipitation in space and time is very uneven, leading to tremendous temporal variability in water resources worldwide (Oki et al, 2006).

For example, the Atacama Desert in Chile, the driest place on earth, receives imperceptible annual quantities of rainfall each year. On the other hand, Mawsynram, Assam, India receives over 450 inches annually. If all the freshwater on the planet were divided equally among the global population, there would be 5,000 to 6,000 m3 of water available for everyone, every year (Vorosmarty 2000).

Second, the rate of evaporation varies a great deal, depending on temperature and relative humidity, which impacts the amount of water available to replenish groundwater supplies.

The combination of shorter duration but more intense rainfall (meaning more runoff and less infiltration) combined with increased evapotranspiration (the sum of evaporation and plant transpiration from the earth's land surface to atmosphere) and increased irrigation is expected to lead to groundwater depletion (Konikow and Kendy 2005).

The Hydrological Cycle

The hydrological cycle begins with evaporation from the surface of the ocean or land, continues as the atmosphere redistributes the water vapor to locations where it forms clouds, and then returns to the surface as precipitation. The cycle ends when the precipitation is either absorbed into the ground or runs off to the ocean, beginning the process over again.

Key changes to the hydrological cycle (associated with an increased concentration of greenhouse gases in the atmosphere and the resulting changes in climate) include:

- Changes in the seasonal distribution and amount of precipitation.
- An increase in precipitation intensity under most situations.
- Changes in the balance between snow and rain.
- Increased evapotranspiration and a reduction in soil moisture.
- Changes in vegetation cover resulting from changes in temperature and precipitation.
- Consequent changes in management of land resources.
- Accelerated melting glacial ice.
- Increases in fire risk in many areas.
- Increased coastal inundation and wetland loss from sea level rise.
- Effects of CO_2 on plant physiology, leading to reduced transpiration and increased water use efficiency (Goudie 2006).

Changes in Precipitation and Drought Patterns

Projections of changes in total annual precipitation indicate that increases are likely in the tropics and at high latitudes, while decreases are likely in the sub-tropics, especially along its poleward edge. Thus, latitudinal variation is likely to affect the distribution of water resources. In general, there has been a decrease in precipitation between 10°S and 30°N since the 1980s (IPCC 2007). With the population of these sub-tropical regions increasing, water resources are likely to become more stressed in these areas, especially as climate change intensifies.

While some areas will likely experience a decrease in precipitation, others (such as the tropics and high latitudes) are expected to see increasing amounts of precipitation. More precipitation will increase a region's susceptibility to a variety of factors, including:

- Flooding
- Rate of soil erosion
- Mass movement of land
- Soil moisture availability

These factors are likely to affect key economic components of the GDP such as agricultural productivity, land values, and an area's habitability (IPCC 2007). In addition, warming accelerates the rate of surface drying, leaving less water moving in near-surface layers of soil. Less soil moisture leads to reduced downward movement of water and so less replenishment of groundwater supplies (Nearing et al 2005). In locations where both precipitation and soil moisture decrease, land surface drying is magnified, and areas are left increasingly susceptible to reduced water supplies.

Although projecting how changed precipitation patterns will affect runoff is not yet a precise science, historical discharge records indicate it is likely that for each 1°C rise in temperature, global runoff will increase by 4%. Applying this projection to changes in evapotranspiration and precipitation leads to the conclusion that global runoff is likely to increase 7.8% globally by the end of the century (Oki and Kanae 2006). Thus, a region that experiences higher annual precipitation and more runoff increases the likelihood for flooding. Furthermore, in areas that are already vulnerable due to their limited groundwater storage availability, this cycle intensifies with increased warming and diminishing water supplies. In water stressed regions, variability of precipitation patterns is likely to further reduce groundwater recharge ability. Water availability is likely to be further exacerbated by poor management, elevated water tables, overuse from increasing populations, and an increase in water demand primarily from increased agricultural production (IPCC 2007).

A recent global analysis of variations in the Palmer Drought Severity Index (PDSI) indicated that the area of land characterized as very dry has more than doubled since the 1970s, while the area of land characterized as very wet has slightly declined during the same time period. In certain susceptible regions, increased temperatures have already resulted in diminished water availability. Precipitations in both western Africa and southern Asia have decreased by 7.5% between 1900 and 2005 (Dai et al 2004).

Most of the major deserts in the world including the Namib, Kalahari, Australian, Thar, Arabian, Patagonian and North Saharan are likely to experience decreased amounts of precipitation and runoff with increased warming. In addition, both semiarid and arid areas are expected to experience a decrease and seasonal shift in flow patterns. If increased temperatures cause an intensification of the water cycle there will be more extreme variations in weather events, as droughts will become prolonged and floods will increase in force (Huntington 2005).

MELTING GLACIAL ICE

Water supplies can also be affected by warmer winter temperatures that cause a decrease in the volume of snowpack. The result is diminished water resources during the summer months. This water supply is particularly important at the midlatitudes and in mountainous regions that depend upon glacial runoff to replenish river systems and groundwater supplies. Consequently, these areas will become increasingly susceptible to water shortages with time, because increased temperatures will initially result in a rapid rise in glacial meltwater during the summer months, followed by a decrease in melt as the size of glaciers continue to shrink. This reduction in glacial runoff water is projected to affect approximately one-sixth of the world's population (IPCC 2007).

A reduction of glacial runoff has already been observed in the Andes, whereby the usual trend of glacial replenishment during winter months has been insufficient. This is due to increased temperatures, which have caused the glaciers to retreat. It is likely that Andean communities such as El Alto in Bolivia have already observed a reduction in glacial runoff due to the scattered distribution of smaller sized glaciers, which further reduces the potential for runoff. In these areas, approximately one-third of the drinking water is dependent upon these supplies, and the recurrent trend of increased melt with diminished replenishment provides a dismal projection for water reserves if this same pattern continues (Goudie 2006).

Water Quality

Freshwater bodies have a limited capacity to process the pollution stemming from expanding urban, industrial and agricultural uses. Water quality degradation can be a major source of water scarcity.

Although the IPCC projects that an increase in average temperatures of several degrees□ as a result of climate change will lead to an increase in average global precipitation over the course of the 21st century, this amount does not necessarily relate to an increase in the amount of potable water available.

A decline in water quality can result from the increase in runoff and precipitation-and while the water will carry higher levels of nutrients, it will also contain more pathogens and pollutants. These contaminants were originally stored in the groundwater reserves but the increase in precipitation will flush them out in the discharged water (IPCC 2007).

Similarly, when drought conditions persist and groundwater reserves are depleted, the residual water that remains is often of inferior quality. This is a result of the leakage of saline or contaminated water from the land surface, the confining layers, or the adjacent water bodies that have highly concentrated quantities of contaminants. This occurs because decreased precipitation and runoff results in a concentration of pollution in the water, which leads to an increased load of microbes in waterways and drinking-water reservoirs (IPCC 2007).

One of the most significant sources of water degradation results from an increase in water temperature. The increase in water temperatures can lead to a bloom in microbial populations, which can have a negative impact on human health. Additionally, the rise in water temperature can adversely affect different inhabitants of the ecosystem due to a species' sensitivity to temperature. The health of a body of water, such as a river, is dependent upon its ability to effectively self-purify through biodegradation, which is hindered when there is a reduced amount of dissolved oxygen. This occurs when water warms and its ability to hold oxygen decreases. Consequently, when precipitation events do occur, the contaminants are flushed into waterways and drinking reservoirs, leading to significant health implications (IPCC 2007).

Effects on Coastal Populations

For coastal populations, water quality is likely to be affected by salinization, or increased quantities of salt in water supplies. This will result from a rise in sea levels, which will increase salt concentrations in groundwater and estuaries. Sea-level rise will not only extend areas of salinity, but will also decrease freshwater availability in coastal areas. Saline intrusion is also a result of increased demand due in part to growing coastal populations that leave groundwater reserves increasingly vulnerable to contamination and diminishing water reserves (IPCC 2007).

9

Mountain Geography and Time Zone

A mountain is a large landform that stretches above the surrounding land in a limited area usually in the form of a peak. A mountain is generally steeper than a hill. The adjective montane is used to describe mountainous areas and things associated with them. The study of mountains is called Orography. Exogeology deals with planetary mountains, which in that branch of science are usually called *montes* (singular—*mons*). The highest mountain on earth is the Mount Everest 8,848 m (29,029 ft).. The highest known mountain in the Solar System is Olympus Mons on the planet Mars at 21,171 m (69,459 ft).

DEFINITION

There is no universally accepted definition of a mountain. Elevation, volume, relief, steepness, spacing and continuity has been used as criteria for defining a mountain. In the Oxford English Dictionary a mountain is defined as "a natural elevation of the earth surface rising more or less abruptly from the surrounding level and attaining an altitude which, relatively to the adjacent elevation, is impressive or notable." Whether a landform is called a mountain may depend on usage among the local people. The highest point in San Francisco, California, is called Mount Davidson, notwithstanding its height of 990 feet, which makes it ten feet short of the minimum for a mountain in American appellation.

Similarly, Mount Scott outside Lawton, Oklahoma is only 824 feet from its base to its highest point.

Definitions of "mountain" include:

- Height over base of at least 2,500 m (8,202 ft).
- Height over base of 1,500 m (4,921 ft).–2,500 m (8,202 ft). with a slope greater than 2 degrees.
- Height over base of 1,000 m (3,281 ft).–1,500 m (4,921 ft). with a slope greater than 5 degrees.
- Local (radius 7,000 m (22,966 ft). elevation greater than 300 m (984 ft)., or 300 m (984 ft)–1,000 m (3,281 ft). if local (radius 7,000 m (22,966 ft). elevation is greater than 300 m (984 ft).

By this definition, mountains cover 64% of Asia, 25% of Europe, 22% of South America, 17% of Australia, and 3% of Africa. As a whole, 24% of the Earth's land mass is mountainous and 10% of people live in mountainous regions. Most of the world's rivers are fed from mountain sources, and more than half of humanity depends on mountains for water.

CHARACTERISTICS

High mountains, as well as those located close to the Earth's poles, reach into the colder layers of the atmosphere. They are consequently subject to glaciation, and erosion through frost action. Such processes produce the peak shape.

Some of these mountains have glacial lakes, created by melting glaciers; for example, there are an estimated 3,000 glacial lakes in Bhutan. Mountains can be eroded and weathered, altering their characteristics over time.

Tall mountains have different climatic conditions at the top than at the base, and will thus have different life zones at different altitudes. At the highest elevations, trees cannot grow, and whatever life may be present will be of the alpine type, resembling tundra. Just below the tree line, one may find subalpine forests of needleleaf trees, which can withstand cold, dry conditions.

In regions with dry climates, the tendency of mountains to have higher precipitation as well as lower temperatures also provides for varying conditions, which in turn lead to differing flora and fauna. Some plants and animals found in these zones tend to become isolated since the conditions above and below a particular zone will be inhospitable and thus constrain their movements or dispersal. On the other hand, birds, being capable of flight, may take advantage of montane habitats and migrate into a region that would otherwise not provide appropriate habitat. These isolated ecological systems, or microclimates, are known as sky islands.

The reason mountains are colder than lowlands has to do with how the sun heats the surface of the earth. Practically all the heat at the surface of the Earth comes from the sun, in the form of solar energy. The sun's radiation is absorbed by land and sea, whence the heat is transferred into the air. Air is an insulator, so conduction of heat from the ground to the atmosphere is negligible.

Heat is mainly transferred into the atmosphere through convection and radiation. Warm air rises because of its buoyancy, leading to convective circulation, in the form of thermals, within the lowest layer of the atmosphere, the troposphere. When heat radiates from the surface of the earth, it is released as long-wave radiation, which does not travel through the air efficiently.

This radiant heat is absorbed temporarily by gasses in the atmosphere, such as carbon dioxide and water vapor. Thus, the lower portion of the troposphere—more than 50% of all air lies below the altitude of the summit of Mt. Everest—forms a blanket of air keeping the surface warm. This is the Greenhouse Effect.

The higher one goes in altitude, the less of this blanket there is to keep in the heat. Thus, higher elevations, such as mountains, are colder than surrounding lowlands. Air temperature in the lowest layer of the atmosphere, the troposphere, decreases with gains in altitude.

The rate at which the temperature drops with elevation, called the environmental lapse rate, is not constant (it can fluctuate throughout the day or seasonally and also regionally), but a normal lapse rate is 5.5°C per 1,000 m (3°F per 3,000 ft). The temperature continues to drop up to a height of about 9–16 km, where it does not decrease further. However, this is higher than the highest mountain top.

Mountains are generally less preferable for human habitation than lowlands; the weather is often harsher, and there is little level ground suitable for agriculture. At very high altitudes, there is less oxygen in the air and less protection against solar radiation (UV). Acute mountain sickness (caused by hypoxia—a lack of oxygen in the blood) affects over half of lowlanders who spend more than a few hours above 3,500 meters (11,483 ft).

Many mountains and mountain ranges throughout the world have been left in their natural state, and are today primarily used for recreation, while others are used for logging, mining, grazing, or see little use. Some mountains offer spectacular views from their summits, while others are densely wooded. Summit accessibility is affected by height, steepness, latitude, terrain, weather.

Roads, lifts, or tramways affect accessibility. Hiking, backpacking, mountaineering, rock climbing, ice climbing, downhill skiing, and snowboarding are recreational activities enjoyed on mountains. Mountains that support heavy recreational use (especially downhill skiing) are often the locations of mountain resorts.

Mountains are made up of earth and rock materials. The outermost layer of the Earth or the Earth's crust is composed of six plates. When two plates move or collide each other, vast land areas are uplifted, resulting in the formation of mountains. Depending upon the geological process, as to how the mountains are formed and the mountain characteristics, there are five major types of mountains.

Fold Mountains: Fold mountains are the most common type of mountains. Examples of fold mountains are the Himalayas (Asia), the Alps (Europe). They are formed due to collision of two plates, causing folding of the Earth's crust. The fold that descends on both sides is called anticline; whereas, the fold that ascends from a common low point (on both sides) is called syncline.

Fault-Block Mountains: As the name suggests, fault mountains or fault-block mountains are formed when blocks of rock materials slide along faults in the Earth's crust. There are two types of block mountains, namely the lifted and tilted. In the former type, the mountain has two steep sides; whereas, the tilted type has one steep side and gentle sloping side.

Example of fault-block mountain is the Sierra Nevada mountains (North America). Volcanic Mountains: Volcanic mountains are formed due to volcanic eruptions, for e.g. Mount Fuji (Japan). They are formed when volcanic magma erupts and piles up on the surface of the Earth.

Dome Mountains: Dome mountains are formed when the hot magma rises from the mantle and uplifts the overlying sedimentary layer of the Earth's crust. In the process, the magma is not erupted, but it cools down and forms the core of the mountain. Example of dome mountain is the Navajo Mountain in Utah. They are called dome mountains due to their appearance that resembles dome shape.

Plateau Mountains: Plateau mountains are pseudo mountains that are formed because of erosion. An example of plateau mountain is the Catskill Mountains (New York). They usually occur near the fold mountain ranges.

There are also some mountains that are formed as a result of many forces of the Earth. Though the Rockies in North America is formed due to folding, there are mountains in the same range that are formed by faulting and doming. In nature, there is a continuous process of glaciation, soil erosion, and mechanical and chemical weathering, which altogether play a major role in altering the shape and characteristics of mountains.

Geology

A mountain is usually produced by the movement of lithospheric plates, either orogenic movement or epeirogenic movement. The compressional forces, isostatic uplift and intrusion of igneous matter forces surface rock upward, creating a landform higher than the surrounding features. The height of the feature makes it either a hill or, if higher and steeper, a mountain. The absolute heights of features termed mountains and hills vary greatly according to an area's terrain.

The major mountains tend to occur in long linear arcs, indicating tectonic plate boundaries and activity. Two types of mountain are formed depending on how the rock reacts to the tectonic forces—block mountains or fold mountains.

Compressional forces in continental collisions may cause the compressed region to thicken, so the upper surface is forced upward. To balance the weight of the earth surface, much of the compressed rock is forced *downward*, producing deep “mountain roots”. Mountains therefore form downward as well as upward. However, in some continental collisions part of one continent may simply *override* part of the others, crumpling in the process.

Some isolated mountains were produced by volcanoes, including many apparently small islands that reach a great height above the ocean floor.

Block mountains are created when large areas are widely broken up by faults creating large vertical displacements. This occurrence is fairly common. The uplifted blocks are block mountains or *horsts*.

The intervening dropped blocks are termed *graben*: these can be small or form extensive rift valley systems. This form of landscape can be seen in East Africa, the Vosges, the Basin and Range province of Western North America and the Rhine valley. These areas often occur when the regional stress is extensional and the crust is thinned.

The mid-ocean ridges are often referred to as undersea mountain ranges due to their bathymetric prominence.

Rock that does not fault may fold, either symmetrically or asymmetrically. The upfolds are *anticlines* and the downfolds are *synclines*: in asymmetric folding there may also be recumbent and overturned folds. The Jura Mountains are an example of folding. Over time, erosion can bring about an inversion of relief: the soft upthrust rock is worn away so the anticlines are actually lower than the tougher, more compressed rock of the synclines.

MOUNTAIN RANGE

A mountain range is a chain of mountains bordered by highlands or separated from other mountains by passes or valleys. Individual mountains within the same mountain range do not necessarily have the same geology, though they often do; they may be a mix of different orogeny, for example volcanoes, uplifted mountains or fold mountains and may, therefore, be of different rock.

The Himalaya Range contains the highest mountains on the Earth's surface, the highest of which is Mount Everest. The world's longest mountain range is Ocean Ridge, which runs on the seafloor of five oceans around the world; it has a length of 65,000 kilometres (40,400 mi), and the total length of the system is 80,000 kilometres (49,700 mi).

The Andes is the world's longest mountain range on the surface of a continent; it is 7,000 kilometres (4,300 mi) in length. The Arctic Cordillera is the world's northernmost mountain system and contains the highest point in eastern North America.

Sub-ranges

The mountain systems of the earth are characterized by a tree structure, that is, many mountain ranges have sub-ranges within them. It can be thought of as a parent-child relationship. For example, the Appalachian Mountains range is the parent of other ranges that comprise it, some of which are the White Mountains and the Blue Ridge Mountains.

The White Mountains are a child of the Appalachians, and there are also children of the Whites, including the Sandwich Range and the Presidential Range. Further, the Presidential Range can be broken up into the Northern Presidential Range and Southern Presidential Range.

Climate

The position of mountains influence climate, such as rain or snow. When air masses move up and over mountains, the air cools producing orographic precipitation (rain or snow). As the air descends on the leeward side, it warms again (in accordance with the adiabatic lapse rate) and is drier, having been stripped of much of its moisture. Often, a rain shadow will affect the leeward side of a range.

A mountains location also affects temperature. If the sun is shining from the east, then the eastern side of the mountain will receive sunlight and warmth, while the other side will be shaded and cooled, so certain ecosystems maintain different biological clocks depending on the location of a mountain.

Erosion

Uplifted regions or volcanic caps can undergo erosion, which makes them move resulting in a range of mountains. An example is the English Lake District. Mountain streams carry eroded debris downhill and deposit it in alluvial plains or in deltas. This forms the classical geological chain of events, leading to one type of sedimentary rock formation: erosion, transportation, deposition and compaction.

TIME ZONE

A time zone is a region on Earth, more or less bounded by lines of longitude, that has a uniform, legally mandated standard time, usually referred to as the local time. By convention, the 24 main time zones on Earth compute their local time as an offset from UTC, each time zone boundary being ostensibly 15 degrees east or west of the preceding one.

The reference point for UTC is the Greenwich Meridian (the Prime Meridian), which has a longitude of 0°. Local time is UTC plus the current time zone offset for the location in question.

In theory, the increase proceeds eastward from the eastern boundary of the UTC time zone entered on 0°, increasing by one hour for each 15°, up to the International Date Line (longitude 180°). A corresponding one hour decrease relative to UTC occurs every 15° heading westward from the western boundary of the UTC time zone, up to the International Date Line.

Introduction

Time zones are adjusted seasonally into standard and daylight saving (or summer) variants. Daylight saving time zones (or summer time zones) include an offset (typically +1 hour) for daylight saving time. Standard time zones can be defined by geometrically subdividing the Earth's spheroid into 24 lunes (wedge-shaped sections), bordered by meridians each 15° of longitude apart.

The local time in neighbouring zones would differ by one hour. However, political boundaries, geographical practicalities, and convenience of inhabitants can result in irregularly shaped zones. Moreover, in a few regions, half-hour or quarter-hour differences are in effect.

Before the adoption of time zones, people used local solar time. Originally this was *apparent* or *true* solar time, as shown by a sundial, and later it became *mean* solar time, as kept by most mechanical clocks. Mean solar time has days of equal length, but the difference between mean and apparent solar time, called the equation of time, averages to zero over a year.

The use of local solar time became increasingly awkward as railways and telecommunications improved, because clocks differed between places by an amount corresponding to the difference in their geographical longitude, which was usually not a convenient number.

This problem could be solved by synchronizing the clocks in all localities, but in many places the local time would then differ markedly from the solar time to which people were accustomed. Time zones are a compromise, relaxing the complex geographic dependence while still allowing local time to approximate the mean solar time.

There has been a general trend to set the boundaries of time zones west of their designated meridians in order to create a permanent daylight saving time effect. The increase in worldwide communication has further increased the need for interacting parties to communicate mutually comprehensible time references to one another. Thus, the advance of technology has both forced (rail transport) and enabled (modern timepieces) the development of arbitrary official "time."

Standard Time Zones

Until fairly recently, time zones were based on Greenwich Mean Time (GMT, also called UT1), the mean solar time at longitude 0° (the Prime Meridian). But as a mean solar time, GMT is defined by the rotation of the Earth, which is not constant in rate. So, the rate of atomic clocks was annually changed, or steered, to closely match GMT.

In January 1972, however, atomic clock rates were fixed and predefined leap seconds replaced rate changes. This new time system is called Coordinated Universal Time (UTC). Leap seconds are inserted to keep UTC within 0.9 seconds of UT1.

In this way, local times continue to correspond approximately to mean solar time, while the effects of variations in Earth's rotation rate are confined to simple step changes that can be more easily applied to obtain a uniform time scale

(International Atomic Time or TAI). With the implementation of UTC, nations began to use it in the definition of their time zones instead of GMT. As of 2005, most but not all nations had altered the definition of local time in this way (though many media outlets fail to make a distinction between GMT and UTC). Further change to the basis of time zones may occur if proposals to abandon leap seconds succeed.

Due to daylight saving time, UTC is the local time at the Royal Observatory, Greenwich only between 01:00 UTC on the last Sunday in October and 01:00 UTC on the last Sunday in March.

For the rest of the year, local time there is UTC+01, known in the United Kingdom as British Summer Time (BST). Similar circumstances apply in many other places.

NOTATION OF TIME (ISO 8601)

UTC

If the time is in UTC, add a "Z" directly after the time without a space. "Z" is the zone designator for the zero UTC offset. "09:30 UTC" is therefore represented as "09:30Z" or "0930Z". "14:45:15 UTC" would be "14:45:15Z" or "144515Z". UTC time is also known as "Zulu" time, since "Zulu" is the ICAO spelling alphabet code word for "Z".

Time Zone as Offsets from UTC

Time zone are written as *offset* from UTC in the format ±[hh]:[mm], ±[hh][mm], or ±[hh]. So if the time being described is one hour ahead of UTC (such as the time in Berlin during the winter), the zone designator would be "+01:00", "+0100", or simply "+01".

This is appended to the time in the same way that 'Z' was above. The offset from UTC changes with daylight saving time, e.g. a time offset in Chicago, which is in the North American Central Time Zone, would be ""06:00" for the winter (Central Standard Time) and ""05:00" for the summer (Central Daylight Time).

Abbreviations

Time zones are often represented by abbreviations such as "EST, WST, CST" but these are not part of the international time and date standard ISO 8601 and their uses as sole designator for a time zone is not recommended. Such designations can be ambiguous as some abbreviations may refer to different timezones in other continents for example EST, WST, CST can refer to Eastern, Western or Central, Summer Time or Standard Time in both North America and Australia.

Time Zone Conversions

Conversion between time zones obeys the relationship;

"Time in zone A" " "UTC offset for zone A" = "time in zone B" " "UTC offset for zone B",

In which each side of the equation is equivalent to UTC. (The more familiar term "UTC offset" is used here rather than the term "zone designator" used by the standard.)

The conversion equation can be rearranged to;

"Time in zone B" = "time in zone A" " "UTC offset for zone A" + "UTC offset for zone B",

For example, what time is it in Los Angeles (UTC offset= "08) when the New York Stock Exchange opens at 09:30 ("05)?

Time in Los Angeles = 09:30 " ("05:00) + ("08:00) = 06:30

In Delhi (UTC offset= +5:30), the New York Stock Exchange opens at;

Time in Delhi = 09:30 " ("05:00) + (+5:30) = 20:00.

These calculations become more complicated near a daylight saving boundary (because the UTC offset for zone X is a function of the UTC time).

HISTORY

Greenwich Mean Time (GMT) was established in 1675 when the Royal Observatory was built as an aid to (English) mariners to determine longitude at sea. At the time, each town's local clock in the area was calibrated to its local noon. Therefore, each clock across England had a slightly different time. The first time zone in the world was established by British railway companies on December 1, 1847—with GMT kept by portable chronometers.

This quickly became known as Railway Time. About August

23, 1852, time signals were first transmitted by telegraph from the Royal Observatory, Greenwich. Even though 98% of Great Britain's public clocks were using GMT by 1855, it was not made Britain's legal time until August 2, 1880. Some old clocks from this period have two minute hands—one for the local time, one for GMT. This only applied to the island of Great Britain, not to the island of Ireland.

On November 2, 1868, the then-British colony of New Zealand officially adopted a standard time to be observed throughout the colony, and was perhaps the first country to do so. It was based on the longitude 172°302 East of Greenwich, that is 11 hours 30 minutes ahead of GMT. This standard was known as New Zealand Mean Time.

Timekeeping on the American railroads in the mid 19th century was somewhat confused. Each railroad used its own standard time, usually based on the local time of its headquarters or most important terminus, and the railroad's train schedules were published using its own time.

Some major railroad junctions served by several different railroads had a separate clock for each railroad, each showing a different time; the main station in Pittsburgh, Pennsylvania, for example, kept six different times. One can imagine the confusion for travellers making a long journey that involved several changes of train.

Charles F. Dowd proposed a system of one-hour standard time zones for American railroads about 1863, although he published nothing on the matter at that time and did not consult railroad officials until 1869. In 1870, he proposed four ideal time zones (having north–south borders), the first entered on Washington, D.C., but by 1872 the first was entered 75°W of Greenwich, with geographic borders (for example, sections of the Appalachian Mountains).

Dowd's system was never accepted by American railroads. Instead, U.S. and Canadian railroads implemented a version proposed by William F. Allen, the editor of the *Traveler's Official Railway Guide*. The borders of its time zones ran through railroad stations, often in major cities.

For example, the border between its Eastern and Central time zones ran through Detroit, Buffalo, Pittsburgh, Atlanta, and Charleston. It was inaugurated on Sunday, November 18, 1883, also called "The Day of Two Noons", when each railroad station clock was reset as standard-time noon was reached within each time zone. The zones were named Intercolonial, Eastern, Central, Mountain, and Pacific. Within one year, 85% of all cities with populations over 10,000, about 200 cities, were using standard time.

A notable exception was Detroit (which is about half-way between the meridians of eastern time and central time), which kept local time until 1900, then tried Central Standard Time, local mean time, and Eastern Standard Time before a May 1915 ordinance settled on EST and was ratified by popular vote in August 1916. The confusion of times came to an end when Standard zone time was formally adopted by the U.S. Congress on March 19, 1918, in the Standard Time Act.

U.S. Commissioner of Railroads William H. Armstrong gave the following account of the new railroad time system in his Report to the Secretary of the Interior for 1883.

The question of uniform time standards for railways of the United States has long attracted the attention of railway managers, but Mr. W. F. Allen, editor of the Traveler's Official Guide, and secretary of the time conventions, is entitled to the credit of having perfected the admirable system which was adopted by the general time convention of railway managers, held at Chicago, October 11, 1883, and ratified by the southern railway time convention, held at New York, October 17, 1883.

As this is a subject of great interest to the entire country, a brief synopsis of the general principles governing the proposed plan is deemed appropriate in this report.

Under the present system each railway is operated independently on the local time of some principal point or points on said road, but this plan was found to be highly objectionable, owing to the fact that some fifty standards, intersecting and interlacing each other, were in use throughout the country.

By the plan which has been adopted this number will be reduced to four, the difference in time being one hour between each, viz, the 75th, 90th, 105th, and 120th degrees of longitude west from Greenwich. The adoption of these standards will not cause a difference of more than thirty minutes from the local time at any point which is now used as a standard. The new arrangement goes into effect November 18, 1883, and all changes of time are to occur at the termini of roads, or at the ends of divisions.

The seventy-fifth meridian being almost precisely the central meridian for the system of roads now using standards based upon the time of the Eastern cities, and the ninetieth meridian being equally central for roads now running by the time of Western cities, the time of these meridians has been adopted for the territory which includes 90 percent of the whole railway system of the country.

Nearly all of the larger cities have abolished local time and adopted that of the nearest standard meridian in use by the railways. While the first person to propose a worldwide system of time zones was the Italian mathematician Quirico Filopanti, in his book *Miranda* published in 1858, his idea was unknown outside the pages of his book until long after his death, so it did not influence the adoption of time zones during the 19th century.

He proposed 24 hourly time zones, which he called “longitudinal days”, the first entered on the meridian of Rome. He also proposed a universal time to be used in astronomy and telegraphy.

Canadian Sir Sandford Fleming proposed a worldwide system of time zones in 1879. He advocated his system at several international conferences, thus is widely credited with their invention. In 1876, his first proposal was for a global 24-hour clock, conceptually located at the centre of the Earth and not linked to any surface meridian. In 1879 he specified that his universal day would begin at the anti-meridian of Greenwich (180th meridian), while conceding that hourly time zones might have some limited local use.

He also proposed his system at the International Meridian Conference in October 1884, but it did not adopt his time zones because they were not within its purview. The conference did adopt a universal day of 24 hours beginning at Greenwich midnight, but specified that it “shall not interfere with the use of local or standard time where desirable”.

Nevertheless, most major countries had adopted hourly time zones by 1929. Today, all nations use standard time zones for secular purposes, but they do not all apply the concept as originally conceived. Newfoundland, India, Iran, Afghanistan, Venezuela, Burma, the Marquesas, as well as parts of Australia use half-hour deviations from standard time, and some nations, such as Nepal, and some provinces, such as the Chatham Islands, use quarter-hour deviations. Some countries, most notably China and India, use a single time zone, even though the extent of their territory far exceeds 15° of longitude. Before 1949 China used five time zones.

Nautical Time Zones

Since the 1920s a nautical standard time system has been in operation for ships on the high seas. Nautical time zones are an ideal form of the terrestrial time zone system. Under the system, a time change of one hour is required for each change of longitude by 15°.

The 15° gore that is offset from GMT or UT1 (not UTC) by twelve hours is bisected by the nautical date line into two 7.5° gores that differ from GMT by ±12 hours.

A nautical date line is implied but not explicitly drawn on time zone maps. It follows the 180th meridian except where it is interrupted by territorial waters adjacent to land, forming gaps: it is a pole-to-pole dashed line.

A ship within the territorial waters of any nation would use that nation’s standard time, but would revert to nautical standard time upon leaving its territorial waters. The captain was permitted to change the ship’s clocks at a time of the captain’s choice following the ship’s entry into another time zone. The captain often chooses midnight.

Skewing of Zones

Ideal time zones, such as nautical time zones, are based on the mean solar time of a particular meridian located in the middle of that zone with boundaries located 7.5 degrees east and west of the meridian. In practice, zone boundaries are often drawn much farther to the west with often irregular boundaries, and some locations base their time on meridians located far to the east.

For example, even though the Prime Meridian (0°) passes through Spain and France, they use the mean solar time of 15 degrees east (Central European Time) rather than 0 degrees (Greenwich Mean Time). France previously used GMT, but was switched to CET (Central European Time) during the German occupation of the country during World War II and did not switch back after the war.

There is a tendency to draw time zone boundaries far to the west of their meridians. Many of these locations also use daylight saving time. As a result, in the summer, solar noon in the Spanish town of Muxia occurs on 14:37 (2:37pm) by the clock. This area of Spain never experiences sunset before 18:00 (6pm) local time even in midwinter, despite its lying more than 40 degrees north of the equator.

Near the summer solstice, Muxia has sunset times similar to those of Stockholm, which is in the same time zone and 16 degrees further north. A more extreme example is Nome, Alaska, which is at 165°242 W longitude—just west of centre of the idealized Samoa Time Zone (165°W). Nevertheless, Nome observes Alaska Time (135°W) with DST so it is slightly more than two hours ahead of the sun in winter and over three in summer.

Kotzebue, Alaska, also near the same meridian but north of the Arctic Circle, has an annual event on 9 August to celebrate *two* sunsets in the same 24-hour day, one shortly after midnight at the start of the day, and the other shortly before midnight at the end of the day.

Daylight Saving Time

Many countries, and sometimes just certain regions of countries, adopt daylight saving time (also known as "Summer Time") during part of the year. This typically involves advancing clocks by an hour near the start of spring and adjusting back in autumn ("spring" forward, "fall" back). Some countries also use backward daylight saving over the winter period. Modern DST was first proposed in 1907 and was in widespread use in 1916 as a wartime measure aimed at conserving coal.

Despite controversy, many countries have used it since then; details vary by location and change occasionally. Most countries around the equator do not observe daylight saving time, since the seasonal difference in sunlight is minimal.

Additional Information

- France has twelve time zones including those of France, French Guiana and numerous islands, inhabited and uninhabited. Russia has nine time zones (and used to have 11 time zones before March 2010), eight contiguous zones plus Kaliningrad exclave on the Baltic Sea. The United States has ten time zones (nine official plus that for Wake Island and its Antarctic stations; no official time zone is specified for uninhabited Howland Island and Baker Island). Australia has nine time zones (one unofficial and three official on the mainland plus four for its territories and one more for an Antarctic station not included in other time zones). The United Kingdom has eight time zones for itself and its overseas territories. Canada has six official time zones.
- In terms of area, China is the largest country with only one time zone (UTC+08). China also has the widest spanning time zone. Before 1949, China was separated into five time zones.
- Stations in Antarctica generally keep the time of their supply bases, thus both the Amundsen-Scott South Pole Station (U.S.) and McMurdo Station (U.S.) use New Zealand time (UTC+12 southern winter, UTC+13 southern summer).
- The 27°N latitude passes back and forth across time zones in South Asia. Pakistan: +05, India +05:30, Nepal +05:45, India (Sikkim) +05:30, China +08:00, Bhutan +06:00, India (Arunachal Pradesh) +05:30, Myanmar +06:30. This switching was more odd in 2002, when Pakistan enabled daylight saving time. Thus from west to east, time zones were: +06:00, +05:30, +05:45, +05:30, +08:00, +06:00, +05:30 and +06:30.
- Because the earliest and latest time zones are 26 hours apart, any given calendar date exists at some point on the globe for 50 hours. For example, April 11 begins in time zone UTC+14 at 10:00 UTC April 10, and ends in time zone UTC”12 at 12:00 UTC April 12.

- There are numerous places where three or more time zones meet, for instance at the tri-country border of Finland, Norway and Russia.
- There are 40 time zones. This is due to fractional hour offsets and zones with offsets larger than 12 hours near the International Date Line as well as one unofficial zone in Australia.
- The largest time gap along a political border is the 3.5 hour gap along the border of China (UTC+08) and Afghanistan (UTC+04:30).
- One of the most unusual time zones is the Australian Central Western Time zone (CWST), which is a small strip of Western Australia from the border of South Australia west to 125.5°E, just before Caiguna. It is 8¾ hours ahead of UTC (UTC+08:45) and covers an area of about 35,000 km^2, larger than Belgium, but has a population of about 200. Although unofficial, it is universally respected in the area—without it, the time gap in standard time at 129°E (the WA/SA border) would be 1.5 hours.

10

Geographical Status of Mining Industry in India

Mineral Resources: The country is having a well-developed mining sector, which has vast geological potential with over 20,000 known mineral deposits. Up to the Seventh Plan period (1990), significant progress was made in the development of mineral resources in the country which is amply depicted in the appreciation of mineral inventory. This helped the country to enter the realm of plenty in respect of certain minerals in which it was hitherto deficient.

The discovery of huge bauxite deposits, particularly in the East Coast, is a case in point, which took the country from the phase of a nonentity to one having the fifth largest inventory of bauxite in the world. In the Eighth Plan, greater emphasis was laid on mineral exploration by adoption of improved technologies like remote sensing, geotechniques, etc., particularly for those minerals in which the resource base of the country is poor such as gold, diamond, nickel, tungsten, rock phosphate, sulphur, etc.

The Geological Survey of India, State Directorates of Mining and Geology, Public Sector Units like NMDC, MEC, HCL, CMPDI, HZL, BGML etc. are the agencies for surveying, mapping and exploration of new deposits and reassessment of older deposits/mines. Out of the total area of 3.29 million sq. kms. of the country, systematic geological mapping of 3.15 million sq. kms. have been carried out by GSI. As a result of the cumulative efforts of the various agencies involved, considerable inventory has been added to most of the mineral deposits in the country. The recoverable reserves status of some important minerals.

Today, the reserves details are available for as many as 20,000 mineral deposits all over the country. The Indian Bureau of Mines has prepared inventory of mineral deposits for the country and updates it every five years. The country is self sufficient in case of 36 minerals and, deficient in respect of a number of minerals. The search for minerals did not remain confined to landmass only. It was extended to off shore area and even deep ocean. Result was the discovery of large petroleum deposits in the Arabian Sea which came to be known as Bombay High. The exploration work in the deep ocean led to the discovery of polymetallic nodules bearing cobalt, nickel, copper and manganese at a depth of 3,000 metres. This work earned India the status of Pioneer Investor in seabed mining conferred by the United Nations.

Mineral Production

Mining Leases: The total number of mining leases granted in the country for different minerals as on March 1998 were 9244 covering an area of about 0.7 million hectares and spread over 255 districts in 21 states. The following ten states together account for 93% of the total leases granted: Gujarat (15%), Rajasthan (14.5%), Andhra Pradesh (14%), Madhya Pradesh (13.5%), Karnataka (11%), Tamil Nadu (7%), Orissa (6.5%), Bihar (4.7%), Goa (4.3%) and Mahrashtra (2.4%). Out of 9244 mining leases, 639 (7%) leases were in the public sector covering an area of 0.47 Mha and the balance in the private sector. In all 3100 mines located in 19 states/union territories were reported to have worked during 1999-2000 of which 566 mines belong to fuel minerals, 561 to metallic minerals and 1973 to non-metallic minerals. This may not include all the mines working minor minerals in different states. There were 828 mines in public sector and the rest in private sector. About 80% of the reporting mines were concentrated in seven states namely, Madhya Pradesh, Rajasthan, Gujarat, Andhra Pradesh, Bihar, Orissa and Karnataka. The Public Sector contributes 100% of copper, diamond, lead, silver and zinc and lignite; 98% of coal, 60% of iron ore and 50% of manganese, bauxite, chromite and dolomite in the total mineral production.

The value of mineral production during 1999-2000 was estimated at Rs.452.3 billion of which the contribution from public sector was Rs.378.4 billion (84%). In the total value of mineral production, fuel minerals accounted for Rs.372.3 billion (82%), metallic minerals at Rs.34.2 billion (8%) nonmetallic minerals Rs.18.3 billion (4%) and minor minerals Rs.27.6 billion (6%). The mineral production in 1970-71, 1990-91 and 1999-2000. There has been a rapid growth in the production of coal and lignite, iron ore and limestone in the past three decades.

Mineral Processing and Mineral based Industry: The National Mineral Policy, 1993 facilitated the growth of mineral based industries through investment in the private sector. As per the policy, processing units which desire to develop captive mines to secure assured supplies of raw material are allowed foreign equity participation in the manner and to the extent applicable to such processing units. The major mineral based products are pig iron, sponge iron, crude steel, ferro – alloys (ferro-chrome, ferro- manganese, ferro – silicon, charge-chrome), non ferrous metals (aluminium, copper, lead, zinc), dry cell batteries, cement, asbestos cement, ceramics, glass and glasswares, fertilisers and chemicals. There has been a significant increase in the mineral processing activity in respect of various minerals. This is indicated by 'Production –Processing Index' which denotes the percentage of domestic mine production processed within the country.

SCENARIO BY PRINCIPAL MINERALS

Bauxite

The huge bauxite resources place India fifth amongst bauxite producing countries in the world. The total recoverable resources in the country as on 1.4.1995 are 2,462 million tonnes of which 768.2 million tonnes are under proved, 586.4 million tonnes under probable and 1,107.8 million tonnes under possible category. These deposits spread over a number of States notably Orissa, Andhra Pradesh, Madhya Pradesh, Gujarat, Maharashtra and Bihar. At 86 per cent of the total, the Indian bauxite deposits are predominantly of metallurgical grade. Compared to this, refractory grade at one per cent and chemical grade at 0.36 per cent make the country seriously deficient in these grades. During the year 1999-2000, the production of bauxite was 6.85 million tonnes. The production had gradually picked up after the discovery of East Coast bauxite. It was 4.8 million tonnes in the beginning of the 90s and increased to 6.8 million tonnes mark in the year 1999-2000. The production of came from 166 mines. As much as 81 per cent production was contributed by 30 mines belonging to 9 principal producers which include NALCO, INDALCO, HINDALCO, BALCO, MALCO, Swati Minerals, Saurashtra Calcine Bauxite & Allied Industries, Saurashtra Cements and MP State Mining Corporation. Daily employment in mines is about 7,000 workers.

Amongst the States, Orissa is the leading producing State at 42 per cent. Bihar at 18 per cent, Gujarat at 14 per cent, Maharashtra at 13 per cent and Madhya Pradesh at 10 per cent are other significant contributors to production efforts. The total bauxite consumption in the country was 5.4 million tonnes during the year 1998-99. Of this, about 60 per cent are consumed by metallurgical industry in producing alumina and aluminium and rest is shared by cement, refractory, chemical and abrasive industries. Aluminium industry uses bauxite bearing 58 per cent Al_2O_3. Slightly lower grades are also used for the purpose after blending. About one lakh tonnes of bauxite is exported to countries such as China, Korea, Ukraine and Saudi Arabia. About 610,000 t of aluminium metal is produced in smelters of HINDALCO (Renukoot), NALCO (Angul), BALCO (Korba), INDALCO (Hirakud, Alupuram, Belgaum) and MALCO (Mettur). The country produces alumina for aluminium production and also for exports. Presently the production is around 1.97 million tonnes from the plants of the above companies.

Chromite

As on 1.4.1995, the chromite recoverable resources of the country were 86.23 million tonnes of which 28.68 per cent were under proved category, 35.70 per cent under probable and 34.47 per cent were under possible category. As much as 97 per cent deposits are located in Orissa. About 34 per cent of the reserves are of metallurgical grade and 29 per cent are charge chrome grade. During the year 1999-2000, the chromite production was 1.69 million tonnes which came from 20 mines. Tata Iron and Steel Company, Orissa Mining Corporation, Ferro Alloys Corporation and Indian Metal and Ferro Alloy are the four companies, which contribute 93 per cent production from 11 mines. The production comes mostly from open cast mines. However, there are underground mines in Byrapur, Karnataka and Boula and Kathpal, Orissa. Orissa contributes as much as 99 per cent production. The employment in chromite mines is around 7,000. The chromite ore is consumed in manufacturing ferro alloys including charge chrome, chemicals and refractories.

Copper Ore

Recoverable resources of copper ore were 461 million tonnes as on 1.4.1995. These reserves contain 4.7 million tonnes of copper metal at 1.02 per cent of metal content in the ore. About 40 per cent of the reserves are under proved category. Probable category has 35 per cent and the share of possible category is 25 per cent. Major deposits are located in Madhya Pradesh, Rajasthan and Bihar.

The country produced 3.12 million tonnes of copper ore in 1999-2000 containing 35,000 t of copper metal from mines located in Bihar, Rajasthan, Madhya Pradesh and Sikkim. This production was contributed by 10 mines belonging to Hindustan Copper Ltd and Sikkim Mining Corporation. Mines such as Khetri and Kolihan are highly mechanised underground mines. Chandmari and Malanjkhand are open pits. The later is the largest hardrock open cast mine in the country producing 2 million tonnes of ROM per annum.

The total annual excavation is around 10 million tonnes. Malanjkhand also has a matching concentrator plant. The total employment in copper mines is around 6,000. There are two smelters in the public sector located at Khetri and Ghatsila with installed annual capacity of 31,000 and 16,500 t respectively. These smelters also produce by-products such as gold, silver, selenium, tellurium, nickel sulphate, phosphoric and sulphuric acids. Expansion programme of these smelters to 100,000 t and 25,000 t is under consideration. Two smelters in the private sector have already been commissioned. These belong to Starlit Copper Company (100,000 tpy at Tuticorin) and another owned by Birla Copper (100,000 tpy at Dahej in Gujarat). A smelter by SWIL Ltd based on 50,000 t scrap annually in Bharuch district, Gujarat) and Metadist (150,000 tpy in Amroli district, Gujarat) are under installation at present.

Diamond

Reserves of diamond are found in Madhya Pradesh, Andhra Pradesh and also in Orissa. The recoverable reserves, as on 1.4.1995 were 982,000 carats. Production of diamond during the year 1999-2000 was about 41,000 carats, which was contributed by two mines located in Panna, Madhya Pradesh. The mine owned by National Mineral Development Corporation at Majhgawan accounted for as much as 99 per cent production. Merely one per cent production came from Directorate of Geology and Mining, Madhya Pradesh.

The diamonds produced were of gem variety (29 per cent), off colour (36 per cent) and industrial (35 per cent) variety. The capacity of NMDC mine is to be expanded to 84,000 carats per year. India is one of the largest exporters of cut and polished diamonds in the world. During the year 1998-99 the exports were Rs 19,977 crone of which 37 per cent were imported by the USA. The indigenous production is not adequate for the purpose and therefore, large quantities of rough diamonds are imported by the country. The diamond imports were as much as Rs 15,555 crone during the year 1998-99.

Granite

Granite has been a non-entity till ‘80s when it discovered for itself a fabulous export market particularly due to the spurt in construction activities in the Middle East.

This transformed it into a precious foreign exchange earner. The country has abundant resources of granite and keeping in view the potential for export of granite, an assessment of the available reserves in the country was carried out by several agencies. On account of the efforts made by GSI, IBM and the Directorates of Geology and Mining of different States, it is estimated that the country has as much as 1,027 mil cu m of granite reserves consisting of 160 varieties of different colour and texture. Granite reserves are found in Andhra Pradesh, Bihar, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Meghalaya, Orissa, Rajasthan, Tamil Nadu, and Uttar Pradesh, etc.

During the year 1997-98, the production of granite was 1.19 mil cu m of which 30 per cent was contributed by Tamil Nadu, 27 per cent by Karnataka, 24 per cent by Andhra Pradesh, 9 per cent by Uttar Pradesh and 4 per cent by Rajasthan. Granite mining is carried out through open cast operations of quarrying, block splitting and processing by manual, semi mechanised and mechanised means such as flame jet cutters. The exports of granite was 0.8 million tonnes in 1998-99 of all categories and were valued at Rs 1.0 billion. The exports were mainly destined to USA, China, UAE, Germany and Belgium. Granite comes under the category of 'Minor Minerals' and is therefore administered by the respective State Government. Looking at the significance of granite as foreign exchange earner, there was an opinion that it should be made a major mineral so that there is a uniform policy through out the country in respect of its exploitation. A significant step has been taken in this direction by the Government of India in June 1999 when it promulgated 'Granite Conservation and Development Rules, 1999' in the interest of having a uniform policy for granite development, exploitation and conservation.

Iron Ore

India possesses large resources of good quality iron ore located in a number of States such as Andhra Pradesh, Bihar, Goa, Karnataka, Madhya Pradesh, Maharashtra, Orissa, Rajasthan, etc. The reserves are adequate to meet the growing requirement for indigenous consumption and for exports. As on 1.4.1995, recoverable reserves measure up to 13 billion tonnes (hematite 10 billion tonnes and magnetite 3 billion tonnes) which makes India the sixth richest country in iron ore resources in the world. The reserves are somewhat limited in high grade ore as 8.86 bil t of hematite deposits are of medium quality. Blending of medium grade with high grade for indigenous consumption and for exports has been resorted to meet the quality requirement. Thus the scenario appears to be quite comfortable. Use of iron ore fines has also helped to further improve the situation.

India produced about 73.5 million tonnes of iron ore in 1999-2000 from both public sector and private sector mines. Out of 213 mines (1999-2000), 34 are owned by public sector undertakings, which produce 55 per cent of the total production. Of this, 11 mines have the capacity to produce more than one million tonnes per annum and contribute about 48 per cent of the total output. Private sector also has large mines of which six have annual production capacity exceeding one million tonnes.

These six mines contribute about 16 per cent to the national production. As much as, 25 per cent production comes from Madhya Pradesh followed by Karnataka (21%) and Goa (21%). Approximately, 34,000 persons are employed in Indian iron ore mines. About 47 per cent of the total production, is domestically consumed in iron and steel, sponge iron, ferro alloys, and alloy steel industries. During the year 1999-2000 29.5 million tonnes of iron ore were exported and 50% of the exports are to Japan and 22 per cent to China.

Lead and Zinc Ore

The recoverable resources bearing the twin minerals in the country were 176 million tonnes as on 1.4.1995. These reserves contain 2.2 million tonnes of lead metal and 9.81 million tonnes of zinc metal. The reserves under proved category are 39 per cent whereas probable category has 27 per cent and possible has 34 per cent. As much as 87 per cent reserves are located in the State of Rajasthan with much smaller quantities in Andhra Pradesh, Bihar, Gujarat, Maharashtra, Sikkim, Tamil Nadu and Uttar Pradesh.

The total production in the year 1999-2000 was 2.74 million tonnes with overall 10.70 per cent total metal content comprising 2.06 per cent lead and 8.64 per cent zinc. The entire quantity is produced in the public sector by Hindustan Zinc Ltd. HZL consumes this ore in its smelters having capacity of 1,52,000 zinc metal and 65,000 lead metal. Cadmium, silver, sulphuric acid and phosphoric acid are obtained as by-products in these smelters. Binani in the private sector operates a smelter of 30,000 t capacity based on imported concentrates. Two small lead-smelting plants have been set up in West Bengal and Maharashtra with a total capacity of 24,000 t per annum.

The mines at Zawar, Rajpura-Dariba and Rampura- Agucha are highly mechanised. The first two are underground mines. Rampura-Agucha is an open cast mine of 3000 tad production capacity which is being raised to 4,500 tad. The mine was commissioned in May 1991 together with a smelter at Chandeliya which proved to be a significant step in reducing dependence on imports in the case of both the metals. There are small lead mines at Sargipalli and Agnigundala. Total employment in the mines is approximately 5,000. Small quantity of polymetallic ore bearing copper, lead and zinc is also produced in Sikkim at the rate of 100 tad.

Limestone

Limestone deposits are found all over the country. The total recoverable deposit is a fabulous 75,678 million tonnes. Of this, 16 per cent deposits are under proved category and 23 per cent probable and 61 per cent are under possible categories. Cement grade accounts for 68.8 per cent, 6.5 per cent SMS, 7 per cent BF and 3.75 per cent are Chemical grades.

For the last several years, the production of limestone is more than 100 million tonnes. During the year, 1999-2000 it was 129 million tonnes from 510 opencast mines. Five mines have production capacity exceeding three million tonnes and contribute 14 per cent to the production. There are 13 mines, which produce between two to three million tonnes with the contribution of 24 per cent of the total production. Mines numbering 29 have capacity between 1 to 2 million tonnes and contribute 31 per cent. Thus 69 per cent production comes from mines having production capacity exceeding on million per annum. Large mines are mechanised and are captive to industries such as steel and cement making. Public sector has a share of only 6 per cent.

Limestone is consumed by a large number of industries such as cement, chemical, fertilizers, aluminium, steel, ferro alloys, foundry, glass, paper, sugar, etc. Maximum limestone is consumed by cement industry. During the year 1998-99 as much as 89 per cent limestone was required by cement plants. Depending upon the use to which it is put on account of its specifications, limestone is defined both as a major as well as a minor mineral.

Manganese Ore

As on 1.4.1995, the recoverable reserves of manganese ore were 167 million tonnes of which 24 per cent were under proved category, 29 per cent probable and 47 per cent under possible category. Battery grade accounted for 2.40 million tonnes, ferromanganese 33 million tonnes, medium grade 38.63 million tonnes and BF grade 65.5 million tonnes. As much as 31.6 per cent of the recoverable deposits are located in Orissa, 24.53 per cent in Karnataka, 14.13 per cent in Madhya Pradesh and !0 per cent in Goa. Other States having deposits of manganese ore include Maharashtra, Andhra Pradesh, Bihar, Gujarat and West Bengal.

During the year 1999-2000, 1,57 million tonnes manganese ore was produced in the country, which came from 135 mines, both opencast and underground owned by 78 producers. More than half the production comes from nine mines only each having a production capacity exceeding 50,000 t per annum. Mines belonging to public sector numbering 23 contribute more than 58 per cent of production.

The contribution by Orissa is maximum at 32 per cent, followed by 23 per cent from Maharashtra, 21 per cent from Madhya Pradesh and 18 percent from Karnataka. The employment in mines is approximately 15,000. Indigenously, manganese ore is consumed in a number of industries such as alloy steel, battery, chemicals, ferro alloys, iron and steel, zinc smelter and ceramic glass. The consumption is around one million tonnes per annum. About 10 per cent of the production is exported.

Institutions

There are many institutions which oversee the development of the mining and mineral sector in India. At the Central Government level, there are ministries of Coal & Mines; Steel; Industry; Chemicals & Fertilisers; Atomic Energy, Petroleum & Natural Gas, Environment and Forests and Labour. The Ministry of Mines in the Central Government has the overall responsibility of determining policies and strategies in respect of non-ferrous (aluminium, copper, zinc, gold, nickel etc.) metals. The Ministry of Mines (MoM) is responsible for survey and exploration of all minerals, other than natural gas, petroleum and atomic minerals. The MMR&D Act is administered by the MoM. There are two subordinate offices, 7 public sector companies and three research institutions under the MoM. The Ministry of Coal has the overall responsibility for the development of coal and lignite resources. Sub-ordinate offices under MoM:

Geological Survey of India (GSI): The GSI is the principal agency responsible for the assessment of geological and regional mineral resources of the country. Its areas of operation encompass scientific surveys and research, for locating mineral resources. GSI operates through six regional offices and four specialised wings – marine, coal geophysics, airborne surveys and training.

The GSI has to its credit geological mapping, covering an area of approximately 3.146; million sq. km, or 94 percent of the area of India. The maps are on a 1:63,360/1:50,000 scale, the data having been synthesised to produce 1:2,000,000 scale geological maps of India, which have been correlated with the global set up as per international standards. The GSI is also actively involved in the research and development of mapping and exploration techniques. It has set up a chain of modern petrological paleontological, chemical, mineralogical, geochronological, geotechnical and geophysical laboratories in its different operational bases, and offers its facilities and services on payment. Geological maps and data are available with GSI on a commercial basis.

Indian Bureau of Mines (IBM): IBM is the principal government agency responsible for compiling exploration data and mineral maps and for providing access to the latest information in respect of mineral resources in the country. IBM has both regulatory as well as service functions. IBM offers technical expertise and proven experience in the fields of geology, mine planning and feasibility studies. The geological services of IBM include survey and preparation of mine plans, preparation of geological plans, preliminary geological appraisal of mineral properties, including the formulation of an initial scheme of detailed exploration with estimate of cost and preliminary reconnaissance, quick survey to determine potential areas out of large properties, etc. IBM also performs regulatory functions, namely: enforcement of Mines and Minerals (Regulation and Development) Act, Mineral concession Rules, Mineral Conservation and Development Rules and compliance with Environmental Protection Act. IBM disseminates statistical information on mines, minerals, metals and mineral based industries through its various publications which are available for sale on commercial basis.

Public Sector Undertaking (PSUs):

- Mineral Exploration Corporation Ltd. (MECL): MECL is responsible for detailed exploration of various minerals/ores by drilling and exploratory mining and proving reserves for their eventual exploitation;
- National aluminium Company Limited (NALCO), Bhubaneswar;
- Bharat Aluminium Company Limited (BALCO), New Delhi;
- Hindustan Zinc Limited (HZL), Udaipur;
- Hindustan Copper Limited (HCL), Kolkata;
- Mineral Exploration Corporation Limited (MECL), Nagpur;
- Bharat Gold Mines Limited (BGML), Kolar Gold Fields (Karnataka);
- Sikkim Mining Corporation (a Company jointly owned by the State Government of Sikkim and the Central Government);
- Research Institutions Legislation and policy.

There is no legislation at the Central Government level on R & R. In 1993, GOI prepared the first draft of a national policy setting out compensation packages and guidelines for R & R. Following widespread consultation within government, however, the draft is still under consideration. Some States, namely Madhya Pradesh, Maharashtra and Karnataka, have enacted legislation for R & R. Others, including Gujarat and Orissa, have adopted formal R & R policies. Similarly, some PSEs have formally adopted R & R policies. Notable among these is Coal India Limited (CIL), who have a comprehensive R & R policy document. Compensation for land, houses and other structures is determined by the provisions of any of the following Acts, depending upon the law applied for acquisition:

(a) The Land Acquisition Act, 1894 (LAA);

(b) The Coal Bearing Areas (Acquisition and Development) Act, 1957 (CBAADA);

(c) Relevant State laws.

SMALL SCALE MINING SECTOR

What is Small Scale Mining?

Small scale mining is carried out in all countries (both developed and developing) and it is estimated that it contributes as much as 15% of the global value of mineral production. Indian mining industry also operates a number of small mines spread throughout the country. Many attempts have been made by researchers in the last three decades to define small scale mining and a number of arbitrary definitions have evolved. These definitions may be categorised into two distinct groups, one uses the mine production as the only yardstick and the other treats the mineral produced by the mine being its marketable output. However, none of these approaches are complete in itself. In India a Committee on Small Mines was set up in 1986 by Mining Geological and Metallurgical Institute of India (MGMI). According to this committee, a small mine is one in which the raw ore production does not exceeds a certain limit depending on the mineral/ore; the investment will not exceed Rs.6 million; and if benefication/processing plants are installed the investment may not exceed Rs.10 million. According to the International Labour Organisation (ILO) the small scale mining falls into two broad based categories. The first is the mining and quarrying of industrial minerals and construction materials on a small scale. These operations are mostly for local markets and they exist in every country. Regulations to control and tax them are often in place. Informal or illegal operations at this level are generally due to a lack of inspection and the lax enforcement of regulations rather than to the lack of a legal framework, much the same as for small manufacturing plants. The second category is the mining of relatively high-value minerals, notably gold and precious stones.

Small Scale Mining in India

The definition of small scale mining operations is highly country specific. A mine which comes under the category of small mines in one country may not be considered so in another country. The definition also depends on a number of factors such as persons employed, bulk and value relationship of mineral, size of the mining lease, size of mineral reserve in that lease, production capacity, labour productivity etc., individually or a combination of any of these factors. Therefore, if a small mine is taken as that operation which is defined by the absence of the regular use of deep blast hole drills, large scale blasting and heavy earth moving equipment with employment of manpower limited to 150 persons underground and 400 overall, then about 95 per cent of mines in India will come in to the category of small mining operations. Out of the 4 fuel, 11 metallic and 49 non metallic industrial minerals, as many as 36 are mined exclusively by small scale sector and another 14 are mined partly by small scale and partly by medium scale operations. Valuewise about 20 per cent of the total production is contributed by small mining operations. Of this figure, 15 per cent comes from major minerals and 5 per cent from minor minerals. Small size operations seem to be more common in the private sector.

The present size of mining operations (productionwise) can be gauged from the aggregate production of minerals and the number of operating mines in respect of 20 minerals which are fairly representative of the non – fuel mineral profile. It will be seen that the average size of mining operations in respect of copper, lead and zinc is much more than other minerals. However, these minerals do have small mining operations, which is indicated by the production levels at a number of mines (Agnigundala, Ingaldhal, Kalyadi, Mailaram., Dariba and Bhotang).

Small scale mines are situated mostly in underdeveloped areas, quite a few operate in clusters and some of them are artisanal. A large number of them are tackling small mineral deposits of ores which may not be amenable to largescale operations. Such minerals are: apatite, asbestos andalucite, baryte, bauxite, bentonite, china clay, chromite, flespar fireclay, graphite, magnetite, mica, ochres, soap stone, quartz, garnet, varieties of rare earths, iron ore, manganese, zinc, fluospar, phosphate, magnesite, granite, marble slate, limestone, etc. In view of the low tenor of ores and small size of some deposits, small scale mining is of great relevance. To make them cost-and-qualitycompetitive, induction of latest but flexible technology can be great value. At present, however, out-dated technology, higher costs of production and poorer quality of products is major handicaps.

Advantages of Small Scale Mining

The small-scale mining sector has certain advantages which are very much pertinent to the Indian socio-economic structure. These are:

- Small mining operations have high employment potential for workers of all types – skilled, semiskilled or unskilled, even in remote rural areas. About one and half decade back 50% of Indian mining workforce was engaged in small mines (Argall, 1976). A recent estimate indicates that around 0.5 million workers in this country are employed by this sector (Berger & Carman, 1990).
- Small mining may also fit in well in the Indian social structure, especially if seasonal operations are required because of the cultivation in the same area.
- The above two factors may collectively act as a restraint to rural population on urban migration.
- Developments of small mines are accomplished more rapidly and at a fraction of the cost of large mining ventures.
- Small scale mines sometimes form the basis for local processing and manufacturing industries either on small or cottage scale, or as feeders to large centralised plants, thus help the socio economic growth of their surroundings.
- Small mining activities respond readily to alterations in economic balance caused by changes in mineral price and provide greater stability to product cost.
- Exploitation being low, exploration success in these mines is usually greater than in larger ventures. Small operations sometimes lead to the recognition of major deposits.

Some Serious Shortcomings

- Less-than-subsistence wages, appalling working conditions and disregard to safety and health are very common.
- Environmental protection is seldom more than rudimentary: Inappropriate technology, lack of consciousness towards mineral conservation, and inadequate financial support often lead to disorganised and wasteful exploitation of mineral deposits.
- Sometimes knowledge and enforcement of statutes are totally missing.
- This sector in India is mainly run by private entrepreneurs. Sometimes, due to remoteness of the locations of small mines and gaps in communication, many of them, specially those of minor minerals, are worked beyond the knowledge of law enforcing authorities like the Directorate General of Mines Safety (DGMS). Neither the mine management, nor even the concerned government departments are duly aware of the statutes concerned with mining activities. As a result, these mines are often worked in unsafe and unscientific fashion.

Cluster Mining

The concept of small scale cluster mining as a means of sustained employment and eco-friendly mining operation is gradually attracting attention all over the world. But the problem of development of such clusters are so diverse (both technical and socio-economic) that each country needs an in-depth study in each case. In India, the cluster concept has been experimented in Pachami-Hatgacha (in the State of West Bengal) stone mining activities. It is reported (by NISM) that in the cluster the employment has increased from about 200 to 10,000 in a period of two decades, providing minimum sustenance to a large number of people. There are two categories of cluster-mining: I) developed naturally in the course of decades of operation and ii) pre-planned and executed under same authority fairly quickly. By way of example, Pakur Stone mining in Bihar, Makrana Marble mining in Rajasthan and Naini Glass Sand mining in Uttar Pradesh can be classified under the first category and

Pachami-Hatgacha Stone mining in Birbhum in West Bengal and, in a way, Panna Diamond mining under the second category. Naturally developed cluster-mining takes a long time to develop and gives rise to employment in a slow and halting manner. This happens as and when the number of mines and production gradually increase some-times with erratically growing market demand and slow development of infrastructural facilities. In such clusters proper and timely geological investigations and scientific analyses and studies are not carried on in time, leaving the entire operation to hit and miss technology except in a few isolated cases of enlightened individuals.

But in the case of preplanned clusters all the necessary preliminary investigations are made and the entrepreneurs helped and guided to carry on operations in an enlightened manner. Thus the development is much quicker on a sure footing leading to production and employment. Moreover, in such cases, chances of introduction of more effective mining methods and better technology (intermediate) is easier and the entrepreneurs are more receptive to suggestions and advice. This was realised during two NISM organised Workshops (1995) on motivating small mine owners for eco-friendly mining operations. But unfortunately, in most of these areas the total advantage of cluster mining can not be harvested for want of adequate follow up and supportive actions by many of the government authorities who are more interested in collecting royalty income than in improving mining activities consistent with safety and protection of environment. They are not much interested in gradually modernising mining and processing practices which not only improve labour wages but also government revenue income.

Future Scenario

Small scale mining provides employment, income and foreign exchange to the country. It enables resources to be developed which otherwise non-economic and it helps to avoid rural-urban migration. It maintains the link between people and the land. Looking at the significance of the small operations in the mining sector, it is advocated that this sector should be extended all support. Small scale mining needs to be given full recognition for its contribution to national wealth and employment and should receive proper consideration when policies and regulations are developed and implemented.

A national policy on Small Scale mining may be formulated covering the following aspects:

- Establishment of a statutory definition for Small Scale Mines in India, (surface and underground operations being defined separately) using - rate of mineral production and overburden removal for surface workings, and production rate and depth of working for underground operations. In addition level of investment, employment, value of the minerals etc. should also be considered
- Execution of elaborate human resource development programme to develop awareness in this sector regarding:
    - safety and health
    - appropriate technology
    - environment
    - statutes
- Improvement of the statutory monitoring to ensure safe and scientific mining
- Provision of financial assistance to small mines for adoption of environment control measures
- Provision of technical support in exploration, planning and quality control

Companies Operating in the Mining Sector

Extensive programme of State disinvestment from public sector companies (including mining companies) have been initiated in India. Privatisation can take a variety of forms:

1. Regulation of state assets through full divestment of states interests
2. Partial sale of state ownership
3. Injection of private capital for the development of new ventures

In the non-coal mining companies, the approach 2 is being followed, whereas for the coal sector the approach 3 is being followed. The case of some public sector companies are discussed below.

The privatisation of natural resources, energy and infrastructure sectors reflects a fundamental reappraisal of the state's role in the development of natural resources for national benefit. The state's direct role from being the owner, operator and regulator of mineral production is being reduced to that of a facilitator of mineral production. The state aims to ensure social benefits from mineral extraction through the mechanism of regulation and taxation.

BHARAT ALUMINIUM COMPANY LTD (BALCO)

BALCO is one of the profit making companies in the country. It makes a net profit of about Rs 100 crore with a turnover of Rs 1,000 crore. The paid up share capital is Rs 500 crore and networth is Rs 600 crore. Initially three organizations were taking interest in acquiring shares of BALCO. These included HINDALCO in association with ALCOA, NALCO and Sterlite Industries. However, NALCO opted out soon after. Jardine Fleming India Securities Ltd. worked as advisors for disinvestment purposes. The evaluation of shares was carried out based on discounted cash flow, balance sheets and assets. The decision went in favour of the Mumbai based Sterlite Industries, which bought 51 per cent shares of BALCO for Rs 551=50 crore. The company has interests in copper and aluminium. However, as soon as the acquisition of BALCO took place, it did not go well with the newly carved State of Chhattisgarh, local authorities, Unions and workers. Work was struck for a long period of 67 days, which could be resumed only on 9th May 2001 after an agreement on 24 demands was arrived at. These demands were primarily on personnel matters. It was assured that there would not be any retrenchment for one year, and a voluntary scheme thereafter will be floated to shed the excess flab.

The Hon. Supreme Court approved the deal of acquisition of BALCO by Sterlite in its judgment of 10.12.2001. BALCO is in need of upgradation of technology as it has been operating on the technology, which is two decades old by now. Also, upscaling of alumina and smelting facilities is necessary. Meanwhile, Orissa State has allotted to BALCO a bauxite mine, Sashubohumali, in Koraput district, which has reserves of 30 million tonnes of high grade mineral.

HINDUSTAN ZINC LIMITED (HZL)

HZL is another public sector undertaking with a very sound infrastructure. It produces 65 per cent of the zinc in the country and also substantial quantities of lead, silver and sulphuric acid. HZL is planning to have a green field zinc smelter at Kapasan in Rajasthan, which will have annual capacity of 100,000 t. At present the Government of India holds 75.92 per cent shares, 24.08 per cent having been already sold to the public as far back as 1992-93. It is now proposed to make over another 26 per cent to a strategic partner with a five-year lock in period. Government of India will therefore, retain 49.92 per cent shares. However the Government plans to have its six Directors including the Chairman on the 11-member Board. The remaining five Directors including the Managing Director will come from the strategic partner. As many as eight companies have indicated interest in acquiring the shares of HZL, which include Sterlite Industries, Indo-Gulf Corporation, Glancore International, Phelps Dodge, etc. The bidder is required to have a turnover of at least Rs 650 crore per annum and a networth of Rs 350 crore. BNP-Paribas has been appointed as a global advisor.

NATIONAL ALUMINIUM COMPANY LIMITED (NALCO)

NALCO is one PSU, which has been doing consistently well over the last several years. Its operating margin is 38.9 per cent compared to another aluminium manufacturer BALCO at 8.2 per cent. The authorized capital is Rs. 300 crore and paid up capital is Rs 644.31 crore. NALCO has expanded its mining capacity to 2.8 from 2.4 million tonnes per annum. Further expansion plans include alumina from 800,000 to 105,000 t, bauxite from 2.8 to 4.8 million tonnes, aluminium from 230,000 to 345,000 t and power from 720 to 840 mw at a total estimated cost of Rs 4,000 crore. NALCO is considering diversification in manufacturing wheels, car components, zeolite and special grade alumina. The Company was also to sign an agreement with the Moscow Institute of Steel Alloys and Romelt Sail of India Ltd.

to have a project for extracting pig iron from red mud. NALCO has already shed its 13 per cent shares to financial institutions, retail investors and employees. Further 30 per cent shares are under consideration for being off loaded to bring the same down to 57 per cent. However, in a recent development, the Parliament Standing Committee on Industry has recommended that the disinvesment of NALCO may be avoided and assistance should be given to increase its presence in the international market.

NATIONAL MINERAL DEVELOPMENT CORPORATION (NMDC)

NMDC is one PSU, which is presently giving excellent results. The present holding of the Central Government in NMDC is 96.36 per cent. A small part of the holding, 1.62 per cent has already been off loaded. The rest is with the State Government and other collaborators. Disinvestment Commission has recommended 20-25 per cent FDI, which also includes a joint venture to bring latest technology and management practices.

KUDREMUKH IRON ORE COMPANY LIMITED (KIOCL)

KIOCL has an iron ore mine, which is performing well in spite of all odds in the past and also in the present. The present problem is on account of delays in getting the renewal of the mining lease for a reasonable period. KIOCL is a profit-making company. The disinvestment to the extent of 74 per cent has been planned leaving 26 per cent with the Government. The plans have been deferred for the time being, pending finalization of mining lease extension.

HINDUSTAN COPPER LIMITED (HCL)

At present HCL is in a lot of financial problems as the company is incurring severe losses primarily because of the depressed prices of copper metal in the international market. The accumulated losses are as much as Rs 300 crore and liabilities total up to Rs 150 crore. Another Rs 150 may be required to overhaul the present facilities. HCL is planning to hive off its facilities in Khetri and Taloja in another company by allowing the joint venture partner to acquire 51 per cent stake. The disinvestment has been kept on hold for the time being as the Unions are taking time in appreciating the value assigned to the shares.