ENVIRONMENT LAW, POLLUTION AND PROTECTION

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Preface

Environmental law, pollution, and protection are interconnected facets of legal frameworks aimed at preserving the natural world and mitigating human impact on the environment. At its core, environmental law establishes regulations and standards to safeguard ecosystems, wildlife, air, water, and land from pollution and degradation. These laws encompass a wide range of issues, including pollution control, waste management, conservation, and climate change mitigation.

Pollution, whether from industrial activities, transportation, or other sources, poses significant threats to environmental and public health. Environmental laws set limits on emissions and discharges, establish pollution control measures, and mandate the cleanup of contaminated sites to prevent further harm to the environment and human populations.

Protection of the environment involves a multifaceted approach, encompassing regulatory measures, enforcement mechanisms, and conservation efforts. Laws governing conservation and biodiversity protection aim to preserve natural habitats, endangered species, and ecological diversity for future generations. Additionally, measures addressing climate change focus on reducing greenhouse gas emissions, promoting renewable energy sources, and adapting to the impacts of a changing climate.

Enforcement of environmental laws is essential to ensure compliance and accountability. Government agencies tasked with monitoring environmental compliance investigate violations and enforce penalties against individuals or corporations found responsible for environmental harm or non-compliance with regulations. Civil and criminal penalties may be imposed to deter pollution and environmental degradation.

Public participation, education, and advocacy play a crucial role in environmental protection efforts. Community involvement and grassroots movements raise awareness about environmental issues, advocate for stronger regulations, and promote sustainable practices at the local, national, and international levels.

International cooperation is also vital for addressing global environmental challenges. Treaties, agreements, and conventions facilitate collaboration among nations to address transboundary pollution, protect shared resources, and promote sustainable development practices on a global scale.

Overall, environmental law, pollution control, and protection efforts are essential for safeguarding the planet's natural resources, preserving biodiversity, and ensuring a sustainable future for all. By implementing effective legal frameworks and collective action, society can address environmental challenges and promote harmony between human activities and the natural world.

"In 'Environmental Law: Addressing Pollution and Promoting Protection,' readers explore legal frameworks and strategies aimed at preserving ecosystems and mitigating environmental degradation."

–Author

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An Introduction

Environmental law is a collective term that seeks to encompass aspects of the law that aim to provide protection of the environment. A related but distinct set of regulatory regimes, now strongly influenced by environmental legal principles, focus on the management of specific natural resources, such as forests, minerals, or fisheries. Other areas, such as environmental impact assessment, may not fit neatly into either category, but are nonetheless important components of environmental law.

HISTORY

Early examples of legal enactments designed to consciously preserve the environment, for its own sake or human enjoyment, are found throughout history. In the common law, the primary protection was found in the law of nuisance, but this only allowed for private actions for damages or injunctions if there was harm to land.

Thus, smells emanating from pig sties, strict liability against dumping rubbish, or damage from exploding dams. Private enforcement, however, was limited and found to be woefully inadequate to deal with major environmental threats, particularly threats to common resources. During the "Great Stink" of 1858, the dumping of sewerage into the River Thames began to smell so ghastly in the summer heat that Parliament had to be evacuated. Ironically, the Metropolitan Commission of Sewers Act 1848 had allowed the Metropolitan Commission for Sewers to close cesspits around the city in an attempt to "clean up" but this simply led people to pollute the river. In 19 days, Parliament passed a further Act to build the London sewerage system. London also suffered from terrible

air pollution, and this culminated in the "Great Smog" of 1952, which in turn triggered its own legislative response: the Clean Air Act 1956. The basic regulatory structure was to set limits on emissions for households and business (particularly burning coal) while an inspectorate would enforce compliance.

Notwithstanding early analogues, the concept of "environmental law" as a separate and distinct body of law is a twentieth-century development. The recognition that the natural environment was fragile and in need of special legal protections, the translation of that recognition into legal structures, the development of those structures into a larger body of "environmental law," and the strong influence of environmental law on natural resource laws, did not occur until about the 1960s.

At that time, numerous influences - including a growing awareness of the unity and fragility of the biosphere; increased public concern over the impact of industrial activity on natural resources and human health; the increasing strength of the regulatory state; and more broadly the advent and success of environmentalism as a political movement - coalesced to produce a huge new body of law in a relatively short period of time.

While the modern history of environmental law is one of continuing controversy, by the end of the twentieth century environmental law had been established as a component of the legal landscape in all developed nations of the world, many developing ones, and the larger project of international law.

POLLUTION CONTROL

Air Quality

Air quality laws govern the emission of air pollutants into the atmosphere. A specialized subset of air quality laws regulate the quality of air inside buildings. Air quality laws are often designed specifically to protect human health by limiting or eliminating airborne pollutant concentrations. Other initiatives are designed to address broader ecological problems, such as limitations on chemicals that affect the ozone layer, and emissions trading programmes to address acid rain or climate change. Regulatory efforts include identifying and categorizing air pollutants, setting limits on acceptable emissions levels, and dictating necessary or appropriate mitigation technologies.

Water Quality

Water quality laws govern the release of pollutants into water resources, including surface water, ground water, and stored drinking water. Some water quality laws, such as drinking water regulations, may be designed solely with reference to human health. Many others, including restrictions on the alteration of the chemical, physical, radiological, and biological characteristics of water resources, may also reflect efforts to protect aquatic ecosystems more broadly. Regulatory efforts may include identifying and categorizing water pollutants, dictating acceptable pollutant concentrations in water resources, and limiting

pollutant discharges from effluent sources. Regulatory areas include sewage treatment and disposal, industrial and agricultural waste water management, and control of surface runoff from construction sites and urban environments.

Waste Management

Waste management laws govern the transport, treatment, storage, and disposal of all manner of waste, including municipal solid waste, hazardous waste, and nuclear waste, among many other types. Waste laws are generally designed to minimize or eliminate the uncontrolled dispersal of waste materials into the environment in a manner that may cause ecological or biological harm, and include laws designed to reduce the generation of waste and promote or mandate waste recycling. Regulatory efforts include identifying and categorizing waste types and mandating transport, treatment, storage, and disposal practices.

Contaminant Cleanup

Environmental cleanup laws govern the removal of pollution or contaminants from environmental media such as soil, sediment, surface water, or ground water. Unlike pollution control laws, cleanup laws are designed to respond after-the-fact to environmental contamination, and consequently must often define not only the necessary response actions, but also the parties who may be responsible for undertaking (or paying for) such actions. Regulatory requirements may include rules for emergency response, liability allocation, site assessment, remedial investigation, feasibility studies, remedial action, post-remedial monitoring, and site reuse.

Chemical Safety

Chemical safety laws govern the use of chemicals in human activities, particularly man-made chemicals in modern industrial applications. As contrasted with media-oriented environmental laws (*e.g.*, air or water quality laws), chemical control laws seek to manage the (potential) pollutants themselves. Regulatory efforts include banning specific chemical constituents in consumer products (*e.g.*, Bisphenol A in plastic bottles), and regulating pesticides.

RESOURCE SUSTAINABILITY

Impact Assessment

Environmental impact assessment (EA) is the assessment of the environmental consequences (positive negative) of a plan, policy, programme, or actual projects prior to the decision to move forward with the proposed action. In this context, the term "environmental impact assessment" (EIA) is usually used when applied to actual projects by individuals or companies and the term "strategic environmental assessment" (SEA) applies to policies, plans and programmes most often proposed by organs of state. It is a tool of environmental management forming a part of

project approval and decision-making. Environmental assessments may be governed by rules of administrative procedure regarding public participation and documentation of decision making, and may be subject to judicial review.

Water Resources

Water resources laws govern the ownership and use of water resources, including surface water and ground water. Regulatory areas may include water conservation, use restrictions, and ownership regimes.

Mineral Resources

Mineral resource laws cover several basic topics, including the ownership of the mineral resource and who can work them. Mining is also affected by various regulations regarding the health and safety of miners, as well as the environmental impact of mining.

Forest Resources

Forestry laws govern activities in designated forest lands, most commonly with respect to forest management and timber harvesting. Ancillary laws may regulate forest land acquisition and prescribed burn practices. Forest management laws generally adopt management policies, such as multiple use and sustained yield, by which public forest resources are to be managed. Governmental agencies are generally responsible for planning and implementing forestry laws on public forest lands, and may be involved in forest inventory, planning, and conservation, and oversight of timber sales. Broader initiatives may seek to slow or reverse deforestation.

Wildlife and Plants

Wildlife laws govern the potential impact of human activity on wild animals, whether directly on individuals or populations, or indirectly via habitat degradation. Similar laws may operate to protect plant species. Such laws may be enacted entirely to protect biodiversity, or as a means for protecting species deemed important for other reasons.

Regulatory efforts may including the creation of special conservation statuses, prohibitions on killing, harming, or disturbing protected species, efforts to induce and support species recovery, establishment of wildlife refuges to support conservation, and prohibitions on trafficking in species or animal parts to combat poaching.

Fish and Game

Fish and game laws regulate the right to pursue and take or kill certain kinds of fish and wild animal (game). Such laws may restrict the days to harvest fish or game, the number of animals caught per person, the species harvested, or the weapons or fishing gear used. Such laws may seek to balance dueling needs for preservation and harvest and to manage both environment and populations of

fish and game. Game laws can provide a legal structure to collect license fees and other money which is used to fund conservation efforts as well as to obtain harvest information used in wildlife management practice.

PRINCIPLES

Environmental law has developed in response to emerging awareness of and concern over issues impacting the entire world. While laws have developed piecemeal and for a variety of reasons, some effort has gone into identifying key concepts and guiding principles common to environmental law as a whole. The principles discussed below are not an exhaustive list and are not universally recognized or accepted. Nonetheless, they represent important principles for the understanding of environmental law around the world.

Sustainable Development

Defined by the United Nations Environment Programme as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs," sustainable development may be considered together with the concepts of "integration" (development cannot be considered in isolation from sustainability) and "interdependence" (social and economic development, and environmental protection, are interdependent). Laws mandating environmental impact assessment and requiring or encouraging development to minimize environmental impacts may be assessed against this principle.

The modern concept of sustainable development was a topic of discussion at the 1972 United Nations Conference on the Human Environment (Stockholm Conference), and the driving force behind the 1983 World Commission on Environment and Development (WCED, or Bruntland Commission). In 1992, the first UN Earth Summit resulted in the Rio Declaration, Principle 3 of which reads: "The right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations." Sustainable development has been a core concept of international environmental discussion ever since, including at the World Summit on Sustainable Development (Earth Summit 2002), and the United Nations Conference on Sustainable Development (Earth Summit 2012, or Rio+20).

Equity

Defined by UNEP to include intergenerational equity - "the right of future generations to enjoy a fair level of the common patrimony" - and intragenerational equity - "the right of all people within the current generation to fair access to the current generation's entitlement to the Earth's natural resources" - environmental equity considers the present generation under an obligation to account for long-term impacts of activities, and to act to sustain the global environment and resource base for future generations. Pollution control and resource management laws may be assessed against this principle.

Transboundary Responsibility

Defined in the international law context as an obligation to protect one's own environment, and to prevent damage to neighbouring environments, UNEP considers transboundary responsibility at the international level as a potential limitation on the rights of the sovereign state. Laws that act to limit externalities imposed upon human health and the environment may be assessed against this principle.

Public Participation and Transparency

Identified as essential conditions for "accountable governments,... industrial concerns," and organizations generally, public participation and transparency are presented by UNEP as requiring "effective protection of the human right to hold and express opinions and to seek, receive and impart ideas,... a right of access to appropriate, comprehensible and timely information held by governments and industrial concerns on economic and social policies regarding the sustainable use of natural resources and the protection of the environment, without imposing undue financial burdens upon the applicants and with adequate protection of privacy and business confidentiality," and "effective judicial and administrative proceedings."

These principles are present in environmental impact assessment, laws requiring publication and access to relevant environmental data, and administrative procedure.

Precautionary Principle

One of the most commonly encountered and controversial principles of environmental law, the Rio Declaration formulated the precautionary principle as follows:

In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation. The principle may play a role in any debate over the need for environmental regulation.

Prevention

The concept of prevention . . . can perhaps better be considered an overarching aim that gives rise to a multitude of legal mechanisms, including prior assessment of environmental harm, licensing or authorization that set out the conditions for operation and the consequences for violation of the conditions, as well as the adoption of strategies and policies.

Emission limits and other product or process standards, the use of best available techniques and similar techniques can all be seen as applications of the concept of prevention.

Polluter Pays Principle

The polluter pays principle stands for the idea that "the environmental costs of economic activities, including the cost of preventing potential harm, should be internalized rather than imposed upon society at large." All issues related to responsibility for cost for environmental remediation and compliance with pollution control regulations involve this principle.

Theory

Environmental law is a continuing source of controversy. Debates over the necessity, fairness, and cost of environmental regulation are ongoing, as well as regarding the appropriateness of regulations vs. market solutions to achieve even agreed-upon ends. Allegations of scientific uncertainty fuel the ongoing debate over greenhouse gas regulation, and are a major factor in debates over whether to ban particular pesticides. In cases where the science is well-settled, it is not unusual to find that corporations intentionally hide or distort the facts, or sow confusion. It is very common for regulated industry to argue against environmental regulation on the basis of cost. Difficulties arise in performing cost-benefit analysis of environmental issues. It is difficult to quantify the value of an environmental value such as a healthy ecosystem, clean air, or species diversity. Many environmentalists' response to pitting economy vs. ecology is summed up by former Senator and founder of Earth Day Gaylord Nelson, "The economy is a wholly owned subsidiary of the environment, not the other way around." Furthermore, environmental issues are seen by many as having an ethical or moral dimension, which would transcend financial cost. Even so, there are some efforts underway to systemically recognize environmental costs and assets, and account for them properly in economic terms.

While affected industries spark controversy in fighting regulation, there are also many environmentalists and public interest groups who believe that current regulations are inadequate, and advocate for stronger protection. Environmental law conferences - such as the annual Public Interest Environmental Law Conference in Eugene, Oregon - typically have this focus, also connecting environmental law with class, race, and other issues. An additional debate is to what extent environmental laws are fair to all regulated parties. For instance, researchers Preston Teeter and Jorgen Sandberg highlight how smaller organizations can often incur disproportionately larger costs as a result of environmental regulations, which can ultimately create an additional barrier to entry for new firms, thus stifling competition and innovation.

AROUND THE WORLD

International Law

Global and regional environmental issues are increasingly the subject of international law. Debates over environmental concerns implicate core principles

of international law and have been the subject of numerous international agreements and declarations. Customary international law is an important source of international environmental law. These are the norms and rules that countries follow as a matter of custom and they are so prevalent that they bind all states in the world. When a principle becomes customary law is not clear cut and many arguments are put forward by states not wishing to be bound. Examples of customary international law relevant to the environment include the duty to warn other states promptly about icons of an environmental nature and environmental damages to which another state or states may be exposed, and Principle 21 of the Stockholm Declaration ('good neighbourliness' or sic utere).

Numerous legally binding international agreements encompass a wide variety of issue-areas, from terrestrial, marine and atmospheric pollution through to wildlife and biodiversity protection. International environmental agreements are generally multilateral (or sometimes bilateral) treaties (a.k.a. convention, agreement, protocol, *etc.*). Protocols are subsidiary agreements built from a primary treaty. They exist in many areas of international law but are especially useful in the environmental field, where they may be used to regularly incorporate recent scientific knowledge. They also permit countries to reach agreement on a framework that would be contentious if every detail were to be agreed upon in advance. The most widely known protocol in international environmental law is the Kyoto Protocol, which followed from the United Nations Framework Convention on Climate Change.

While the bodies that proposed, argued, agreed upon and ultimately adopted existing international agreements vary according to each agreement, certain conferences, including 1972's United Nations Conference on the Human Environment, 1983's World Commission on Environment and Development, 1992's United Nations Conference on Environment and Development and 2002's World Summit on Sustainable Development have been particularly important. Multilateral environmental agreements sometimes create an International Organization, Institution or Body responsible for implementing the agreement. Major examples are the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and the International Union for Conservation of Nature (IUCN).

International environmental law also includes the opinions of international courts and tribunals. While there are few and they have limited authority, the decisions carry much weight with legal commentators and are quite influential on the development of international environmental law. One of the biggest challenges in international decisions is to determine an adequate compensation for environmental damages. The courts include the International Court of Justice (ICJ), the international Tribunal for the Law of the Sea (ITLOS), the European Court of Justice, European Court of Human Rights and other regional treaty tribunals.

Africa

According to the International Network for Environmental Compliance and Enforcement (INECE), the major environmental issues in Africa are "drought

and flooding, air pollution, deforestation, loss of biodiversity, freshwater availability, degradation of soil and vegetation, and widespread poverty." The U.S. Environmental Protection Agency (EPA) is focused on the "growing urban and industrial pollution, water quality, electronic waste and indoor air from cookstoves." They hope to provide enough aid on concerns regarding pollution before their impacts contaminate the African environment as well as the global environment.

By doing so, they intend to "protect human health, particularly vulnerable populations such as children and the poor." In order to accomplish these goals in Africa, EPA programmes are focused on strengthening the ability to enforce environmental laws as well as public compliance to them. Other programmes work on developing stronger environmental laws, regulations, and standards.

Asia

The Asian Environmental Compliance and Enforcement Network (AECEN) is an agreement between 16 Asian countries dedicated to improving cooperation with environmental laws in Asia.

These countries include Cambodia, China, Indonesia, India, Maldives, Japan, Korea, Malaysia, Nepal, Philippines, Pakistan, Singapore, Sri Lanka, Thailand, Vietnam, and Lao PDR.

European Union

The European Union issues secondary legislation on environmental issues that are valid throughout the EU (so called regulations) and many directives that must be implemented into national legislation from the 28 member states (national states). Examples are the Regulation (EC) No. 338/97 on the implementation of CITES; or the Natura 2000 network the centerpiece for nature & biodiversity policy, encompassing the bird Directive (79/409/EEC/changed to 2009/147/EC)and the habitats directive (92/43/EEC). Which are made up of multiple SACs (Special Areas of Conservation, linked to the habitats directive) & SPAs (Special Protected Areas, linked to the bird directive), throughout Europe.

EU legislation is ruled in Article 249 Treaty for the Functioning of the European Union (TFEU). Topics for common EU legislation are:

- Climate change
- Air pollution
- Water protection and management
- Waste management
- Soil protection
- Protection of nature, species and biodiversity
- Noise pollution
- Cooperation for the environment with third countries (other than EU member states)
- Civil protection

Middle East

The U.S., Environmental Protection Agency is working with countries in the Middle East to improve "environmental governance, water pollution and water security, clean fuels and vehicles, public participation, and pollution prevention."

Oceania

The main concerns on environmental issues in the Oceanic Region are "illegal releases of air and water pollutants, illegal logging/timber trade, illegal shipment of hazardous wastes, including e-waste and ships slated for destruction, and insufficient institutional structure/lack of enforcement capacity". The Secretariat of the Pacific Regional Environmental Programme (SPREP) is an international organization between Australia, the Cook Islands, FMS, Fiji, France, Kiribati, Marshall Islands, Nauru, New Zealand, Niue, Palau, PNG, Samoa, Solomon Island, Tonga, Tuvalu, USA, and Vanuatu. The SPREP was established in order to provide assistance in improving and protecting the environment as well as assure sustainable development for future generations.

Australia

The Environment Protection and Biodiversity Conservation Act 1999 is the center piece of environmental legislation in the Australian Government. It sets up the "legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places". It also focuses on protecting world heritage properties, national heritage properties, wetlands of international importance, nationally threatened species and ecological communities, migratory species, Commonwealth marine areas, Great Barrier Reef Marine Park, and the environment surrounding nuclear activities. *Commonwealth v Tasmania* (1983), also known as the "Tasmanian Dam Case", is the most influential case for Australian environmental law.

Brazil

The Brazilian government created the Ministry of Environment in 1992 in order to develop better strategies of protecting the environment, use natural resources sustainably, and enforce public environmental policies. The Ministry of Environment has authority over policies involving environment, water resources, preservation, and environmental programmes involving the Amazon.

Canada

The Department of the Environment Act establishes the Department of the Environment in the Canadian government as well as the position Minister of the Environment. Their duties include "the preservation and enhancement of the quality of the natural environment, including water, air and soil quality; renewable resources, including migratory birds and other non-domestic flora

and fauna; water; meteorology;" The Environmental Protection Act is the main piece of Canadian environmental legislation that was put into place March 31, 2000. The Act focuses on "respecting pollution prevention and the protection of the environment and human health in order to contribute to sustainable development." Other principle federal statutes include the Canadian Environmental Assessment Act, and the Species at Risk Act. When provincial and federal legislation are in conflict federal legislation takes precedence, that being said individual provinces can have their own legislation such as Ontario's Environmental Bill of Rights, and Clean Water Act.

China

According to the U.S., Environmental Protection Agency, "China has been working with great determination in recent years to develop, implement, and enforce a solid environmental law framework. Chinese officials face critical challenges in effectively implementing the laws, clarifying the roles of their national and provincial governments, and strengthening the operation of their legal system." Explosive economic and industrial growth in China has led to significant environmental degradation, and China is currently in the process of developing more stringent legal controls. The harmonization of Chinese society and the natural environment is billed as a rising policy priority.

Ecuador

With the enactment of the 2008 Constitution, Ecuador became the first country in the world to codify the Rights of Nature. The Constitution, specifically Articles 10 and 71-74, recognizes the inalienable rights of ecosystems to exist and flourish, gives people the authority to petition on the behalf of ecosystems, and requires the government to remedy violations of these rights. The rights approach is a break away from traditional environmental regulatory systems, which regard nature as property and legalize and manage degradation of the environment rather than prevent it.

The Rights of Nature articles in Ecuador's constitution are part of a reaction to a combination of political, economic, and social phenomena. Ecuador's abusive past with the oil industry, most famously the class-action litigation against Chevron, and the failure of an extraction-based economy and neoliberal reforms to bring economic prosperity to the region has resulted in the election of a New Leftist regime, led by President Rafael Correa, and sparked a demand for new approaches to development. In conjunction with this need, the principle of "Buen Vivir," or good living—focused on social, environmental and spiritual wealth versus material wealth—gained popularity among citizens and was incorporated into the new constitution.

The influence of indigenous groups, from whom the concept of "Buen Vivir" originates, in the forming of the constitutional ideals also facilitated the incorporation of the Rights of Nature as a basic tenet of their culture and conceptualization of "Buen Vivir."

Egypt

The Environmental Protection Law outlines the responsibilities of the Egyptian government to "preparation of draft legislation and decrees pertinent to environmental management, collection of data both nationally and internationally on the state of the environment, preparation of periodical reports and studies on the state of the environment, formulation of the national plan and its projects, preparation of environmental profiles for new and urban areas, and setting of standards to be used in planning for their development, and preparation of an annual report on the state of the environment to be prepared to the President."

India

In India, Environmental law is governed by the Environment Protection Act, 1986. This act is enforced by the Central Pollution Control Board and the numerous State Pollution Control Boards. Apart from this, there are also individual legislations specifically enacted for the protection of Water, Air, Wildlife, *etc.*

Such legislations include:-

- The Water (Prevention and Control of Pollution) Act, 1974
- The Water (Prevention and Control of Pollution) Cess Act, 1977
- The Forest (Conservation) Act, 1980
- The Air (Prevention and Control of Pollution) Act, 1981
- Air (Prevention and Control of Pollution) (Union Territories) Rules, 1983
- The Biological Diversity Act, 2002 and the Wild Life Protection Act, 1972
- Batteries (Management and Handling) Rules, 2001
- Recycled Plastics, Plastics Manufacture and Usage Rules, 1999
- The National Green Tribunal established under the National Green Tribunal Act of 2010 has jurisdiction over all environmental cases dealing with a substantial environmental question and acts covered under the Water (Prevention and Control of Pollution) Act, 1974.
- Water (Prevention and Control of Pollution) Cess Rules, 1978
- Ganga Action Plan, 1986
- The Forest (Conservation) Act, 1980
- Wildlife protection Act, 1972
- The Public Liability Insurance Act, 1991 and the Biological Diversity Act, 2002. The acts covered under Indian Wild Life Protection Act 1972 do not fall within the jurisdiction of the National Green Tribunal. Appeals can be filed in the Hon'ble Supreme Court of India.
- Basel Convention on Control of Transboundary Movements on Hazardous Wastes and Their Disposal, 1989 and Its Protocols
- Hazardous Wastes (Management and Handling) Amendment Rules, 2003

Japan

The Basic Environmental Law is the basic structure of Japan's environmental policies replacing the Basic Law for Environmental Pollution Control and the Nature Conservation Law. The updated law aims to address "global environmental problems, urban pollution by everyday life, loss of accessible natural environment in urban areas and degrading environmental protection capacity in forests and farmlands."

The three basic environmental principles that the Basic Environmental Law follows are "the blessings of the environment should be enjoyed by the present generation and succeeded to the future generations, a sustainable society should be created where environmental loads by human activities are minimized, and Japan should contribute actively to global environmental conservation through international cooperation."

From these principles, the Japanese government have established policies such as "environmental consideration in policy formulation, establishment of the Basic Environment Plan which describes the directions of long-term environmental policy, environmental impact assessment for development projects, economic measures to encourage activities for reducing environmental load, improvement of social infrastructure such as sewerage system, transport facilities, *etc.*, promotion of environmental activities by corporations, citizens and NGOs, environmental education, and provision of information, promotion of science and technology."

New Zealand

The Ministry for the Environment and Office of the Parliamentary Commissioner for the Environment were established by the Environment Act 1986. These positions are responsible for advising the Minister on all areas of environmental legislation.

A common theme of New Zealand's environmental legislation is sustainably managing natural and physical resources, fisheries, and forests. The Resource Management Act 1991 is the main piece of environmental legislation that outlines the government's strategy to managing the "environment, including air, water soil, biodiversity, the coastal environment, noise, subdivision, and land use planning in general."

Russia

The Ministry of Natural Resources and Environment of the Russian Federation makes regulation regarding "conservation of natural resources, including the subsoil, water bodies, forests located in designated conservation areas, fauna and their habitat, in the field of hunting, hydrometeorology and related areas, environmental monitoring and pollution control, including radiation monitoring and control, and functions of public environmental policy making and implementation and statutory regulation."

Vietnam

Vietnam is currently working with the U.S., Environmental Protection Agency on dioxin remediation and technical assistance in order to lower methane emissions. In March 2002, the U.S and Vietnam signed the U.S.,-Vietnam Memorandum of Understanding on Research on Human Health and the Environmental Effects of Agent Orange/Dioxin.

SHIFT IN FEDERALISM IN PUBLIC HEALTH LAW

Bioterrorism and emerging infectious diseases threaten the public health in a way we have not seen in almost a century. States have had sovereignty in the area of public health since colonial existence, and pre-emption exists where food and drugs enter interstate commerce. Federal regulation of food and drugs began with the turn of the twentieth century and was intended to regulate risks to the public health.

However, new threats of bioterrorism and emerging infectious diseases are regulated through the sovereign powers of states, not federal powers. But after the anthrax attacks in the Fall of 2001, the public expected the federal government to provide a defence against bioterrorism as a matter of national security.

Consistent with the shifting federalism concept of the U.S., Constitution, interpreted through The Federalist's principle that "If... the people should in future become more partial to the federal than to the State government, the people ought not to be precluded from giving most of their confidence where they may discover it to be most due," a cooperative federalism model in public health is evidently emerging, in much the same manner as federal environmental law. The following developments in the area of biodefence and public health law are illustrative of the shift in federalism analogous to that of federal environmental law.

As outlined above, in 1956 states were given grants to begin to develop standards for water quality on a state-by-state basis. The failure of the states to use grants for consistent regulation from state to state, which would have ensured a uniform approach to environmental regulation, gave rise to state-shopping by polluting industries to find the state with the least regulation. Each state developed their own standards, leading to as many standards as there were states.

Just as grants to states to develop environmental water quality standards resulted in further creating a disjointed and uncoordinated state-by-state approach, the same approach has begun in preparation for bioterrorism. The Public Health Security and Bioterrorism Preparedness and Response Act of 2002 provides for grants to states to develop plans for biodefence dispersed through the Centers for Disease Control and Prevention ("CDC") to the state departments of public health.

A state-by-state approach to biodefence fails to encompass the overarching priority of national coordination in the event of an attack or the spread of an emerging infectious disease, which could spread much like the interstate nature of water and air pollution.

Grants were also provided as a means to prepare for a bioterrorism attack through the Nunn-Lugar-Domenici Act, to provide funding to purchase new equipment and to attend training in biodefence, beginning well before 9-11 in the mid-1990s. The General Accounting Office ("GAO") cautioned against simply providing grants to the states for training and equipment, warning that "federal officials should be alert to the potential for these governments to use grants to substitute for their own resources in these programmes, essentially converting a targeted federal grant into a general revenue sharing initiative."

Indeed, state and local governments, long neglected budget priorities, needed funding to obtain basics such as fax machines. Urging that national preparedness must hinge on the federal government's ability to form effective partnerships with non-federal entities, the GAO argued that "federal initiatives should be conceived as national, not federal in nature," engaging not only local and state governments in partnerships, but also private partners.

The triggering event for a movement in federalism occurred for federal environmental law in 1970 with the culmination of public demand for the federal government to address the growing problem of environmental pollution. The triggering event for a shift in federalism in public health law occurred with the anthrax attacks of the Fall of 2001, when the public demanded that the federal government provide the needed defence and response to the attacks. The role of CDC, however, as stated in its mission, is merely to respond to the needs and requests of states for support and advice in public health matters.

The public demanded more, and the Public Health Security and Bioterrorism Preparedness and Response Act of 2002 provided a token expansion of CDC authority finding that "the Centers for Disease Control and Prevention has an essential role in defending against and combating public health threats and requires secure and modern facilities, and expanded and improved capabilities related to bioterrorism and other public health emergencies, sufficient to enable such Centers to conduct this important mission." A closer examination of the section reveals only that an increase in facilities and training is mandated, rather than an expansion of their mission to fulfill this role of biodefence.

However, the provision for the establishment of a system of public health alert communications and surveillance networks between federal, state, and local public health officials through the use of grants and cooperative agreements is a move away from exclusive state power and control to a more cooperative federalism. The use of surveillance of public health has always been a power of the states, and states are not, therefore, compelled to report any symptoms or diseases other than those reportable communicable diseases required by federal law.

Just as the precipitating event of Earth Day began the shift in federalism in pollution control in environmental law, the precipitating event of the anthrax attacks of the Fall of 2001 has begun a shift in federalism in public health law. The federal government first identified the Public Health Service as the lead agency, followed by the creation of a Federal Water Pollution Control Commission to join with the Public Health Service in administration of water

quality. Pollution control responsibilities were located first in the Public Health Service, then the Commission was made a part of the Department of Health, Education and Welfare.

Finally, the water pollution control authority was transferred to Department of Interior and then to the U.S., Environmental Protection Agency with its formation by Executive Order in 1970 by President Nixon. President Nixon created a new agency with a mission to implement federal environmental law, rather than to risk a "business-as-usual" response by the Department of Interior to the new duties of federal environmental law.

The same reorganization strategy to combine effective federal offices within the Department of Homeland Security parallels the development of federal environmental law, in the shifting federalism responsibilities. President George W. Bush signaled three shifts in federalism in his proposal for the formation of the Department of Homeland Security.

First, "the Department would set national policy and establish guidelines for state and local governments;" second, the proposal makes the Department of Homeland Security "the lead agency preparing for and responding to... biological... terrorism," which takes part of the states' public health agencies' responsibility as described in the CDC biodefence plan; and third, the proposal directs that "The new Department would ensure that local law enforcement entities—and the public—receive clear and concise information from their national government," which again, takes part of the states' public health agencies' responsibility in originating their own public health information.

COMPONENTS OF ENVIRONMENT

Components of environment can be Analysed at various levels *i.e.*, At the level of activities, at the level of processes, and at the level of orientations. Some of these issues and examples are discussed below.

As discussed the following activities have been suggested as components of environmental quality:

- Fire protection.
- Comfort of home.
- Electric service.
- Privacy in your home.
- Relation with fellow workers.
- Postal service.
- Garbage-collection.
- Mechanical helpers in your family.
- Telephone services.
- Public-water system.
- Relation with Neighbours.
- Gas service.
- Freedom to live where you want.
- Sewage disposal service.

- Availability of food around your living place.
- Convenience for getting to important places.
- Noise level in the home setting.
- Beauty of your home.
- Security of your home.
- Topography of land around.
- Product available to the community.
- Medical care in your locality.
- Police protection.
- Quality of water used by the household.
- Natural outdoor recreation.
- Variety of wild life in community.
- Cleanliness of air around.
- Overall weather.
- Public information media.
- Crowding in your residential Neighbourhood.
- Transportation over long distance.
- Level of traffic congestion.
- Job-opportunities.
- Quality of water for recreation.
- Product quality and variety.
- Relations among group in the community.
- Freedom to move from class to class.
- Freedom to move form on job to another.
- Public services-gas, sewage, *etc.*
- Unspoiled natures.
- Man made environment.
- Physical condition of environment at school.
- Isolation of your community.
- Physical condition of environment where you work.
- Amount of open space around.
- Access to parks.
- Control of dogs and other pets.
- Cost of living.

Understanding environment involves studying the complex relationships between the people and the typical physical settings in which they conduct their daily lives. Environmental interest in studying human behaviour in the familiar, everyday physical environment where people live and work as well as its relevance to the environment design and social planning has made it especially responsive to the demands of today's world. Environmental studies are an area of social sciences where the focus of investigation is the interrelationship between the physical environment and human Behaviour and experience of man. Fig below presents this. The other perspective of components of environment relates to environmental processes, its multidisciplinary and applied aspects.

ENVIRONMENTAL PROCESSES

Environment is new subject and a complex field of study. Therefore it is important to consider some of the characteristics that describe the what, how and why of the ways environmental processes work. In this chapter we attempt to explain the adaptation focus, physiological processes, the holistic view, interdisciplinary involvement and applied orientation of the subject matter.

Adaptation Focus

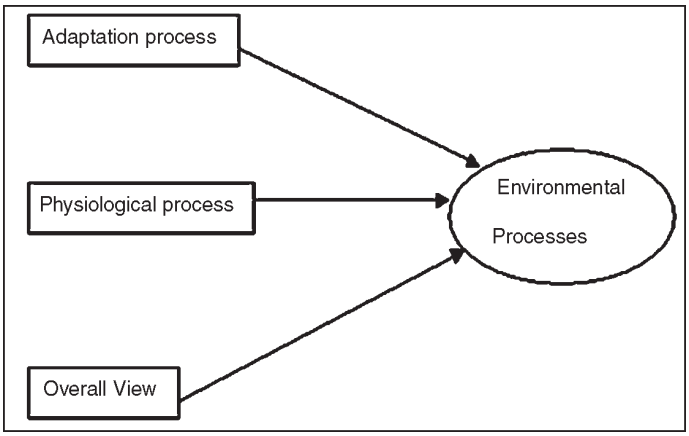
The process of adaptation. It is of interest to study how people adapt to the complex demands of the physical environment. For example, how people live in crowded places or overcrowded setting.

Robert White defines adaptation as encompassing all the processes with their environment. This includes most simple ways of dealing with minor environment and irritations to the most complex efforts to cope with major environment changes. These challenges in living system in interaction with the environment are the adaptation processes. The holistic view of the organism and environment is considered along with the active role of living organism in relation to their environment.

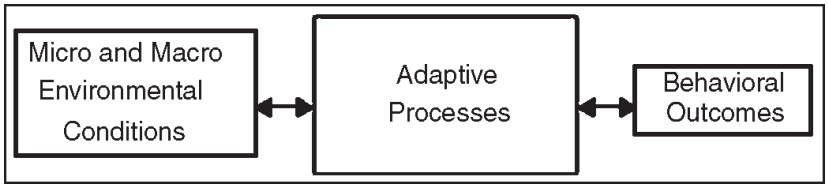
PHYSIOLOGICAL PROCESSES

The adaptation focus of the environment emphasizes the process that mediates the effect of physical setting on human activity *e.g.*, the effect of classroom noise on student's grades.

OVERALL VIEW



Historically, the analysis of the environment was at very small and molecular levels but now the emphasis has shifted from micro to macro level. It is how environment and Behaviour must be seen as interrelated parts of an indivisible whole. The positive and adaptive ways in which people cope with environmental challenges suggest active roles. This view looks into how people have varied and creative ways to cope with their environments.



The adaptation process model (shown above) shows how environment effect on Behaviour is mediated by a number of processes.. It shows that the direction of effect in the environment-Behaviour relationship is reciprocal *i.e.*, people may act on the environmental conditions while the environment in turn also acts on human Behaviour. The negative effects of situation such as over-crowding may be reversed through effective coping processes.

MULTIDISCIPLINARY ORIENTATION

The branches of study here have included not only environment but also other fields such as Sociology, Psychology, Geography, Anthropology, Medicine, Architecture and Planning etc (see figure above). The study of human Behaviour in physical settings requires the works of researchers in many social sciences as well as of architects and planners responsible for the design of human settings. The areas of study include.

APPLIED ORIENTATION

The environmental study has orientation towards both the resolution of practical problem and the formulation of new theories. Lewins action research is a useful model for the intermingling of practical and theoretical needs of the environment.

VALUATION TECHNIQUES

Various techniques, which attempt to means environmental effects, are below.

Preventive Expenditure Techniques

How much people are prepared to spend to prevent degradation of environment can be used as a measure of the value of the environmental effects. It is, however, usually thought that this technique underestimates the value of the environmental effects for various reasons.

If the full scopes of environmental effect including the long-team consequences are beyond the common people's comprehension, the expenditure they would undertake to prevent degradation of environment would all very much short of the required levels. Secondly, it may always not be possible to fully offset all environmental effects by preventive expenditure especially in case of massive investment projects (such as large dams) which cause large environmental changes.

Replacement Cost Techniques

In this technique, how much people are prepared to spend to restore the environment to its previous state after degradation has occurred is taken as a measure of the value of the environmental effects. This technique also suffers

from shortcomings similar to those mentioned in the context of the preventive expenditure technique. It is normally beyond the competence of common people to judge the full scope of damages done to the environment and it is not usually possible to restore the environment to its previous state after it has been damaged.

Property Value Techniques

Real estate values depend on various factors, including environmental factors. A residential accommodation at the lake or with a view to maintain commands a premium in the market. Air pollution depresses price of property in the area. People are willing to pay more for property similar in other respects in areas with clean air. The difference in market price can be used as a measure of the value to society of the cleaner environment. The measurement of this value in practice may however be quite difficult. In order to separate the effect of cleaner environment on properly value from other factors (such as location, quality of neighbourhood, etc) that affect a site's value, one would require to collect data as the value of various sites throughout the area and analyse the data with the help of an appropriates statistical method.

There have been several studies exploring the relationship between air pollution and property values, most of these studies show a significant negative relationship between properly value and air pollution. These studies have, however, been criticized for underestimating the environmental effects of air pollution. People often do not know or understand the severity of pollution problems at different sites.

It requires special expertise to accurately estimate the pollution level at a site. Even if people are told about the presence of air pollutants in the area, they cannot make any use of such information because they lack knowledge about the effects of pollutants on human health or property. In such conditions it is not logical to expect that difference in properly value would correctly estimate the value of environmental effects of air pollution.

Human Health - Effect Technique

One method to estimate the value of environmental effects as to study the effect of pollutant exposures on human health.

It involves putting a monetary value on illness and death caused by exposure to pollutants. This idea of putting money value on human life does not appeal to everyone. Many regard human life to be of infinite value. But, is society's behaviour always consistent with such thinking? IS society prepared to pay whatever is necessary to prevent a death? If human life were considered of infinite value, we would never allow those activities which pose a risk to human beings, given that virtually no economic activity is completely risk-free, and they all would be stopped.

For example, injurious and deaths caused by road accidents could be reduced significantly if laws pertaining to road safely are made very strict. Several studies have shown that appropriate changes in design of vehicles and lowering of

speed limits can reduce the number and severity of traffic accidents significantly. But we know that society does not take all these required steps. This ofcourse, does not mean that human life is cheap. Most people consider it invaluable, if not of infinite value.

One way to determine the effects of exposure to pollutants on human health is to study the incidence of diseases among people. Of course, air pollution is not the role cause of diseases. There are many other explanatory variables such as age, sex, hygienic conditions, climate, living standard and dietary habits. In order to separate the effect of air pollution from other variables, a large body of data on the incidence of various diseases among different sections of the population in various places needs to be collected and analysed with the help of appropriate statistical methods. An alternative method of determining the effects of exposure of pollutants is to conduct Labouratory experiments on plants or animals. Plants animals are exposed to different levels and different kinds of pollutants to study their effects. Rats are often used as study objects for various reasons. The results of such studies, however, cannot be generalized too much. These studies cannot tell much about the effects of pollutants on human health as the human physiology is much different from that of rat or any other animal.

Once the relationship between pollutant exposures and human health effects is determined, the next step is to estimate the value of human health effects in monetary terms. The human health effect technique calculates the value of the health effects by looking at lost economic production and increased health-care costs. The opportunity costs of an individual's premature death can be calculated by estimating the discounted present value of his future earning if he had not died prematurely. This provides a measure of lost economic production and thus a measure of loss to society. In case of illness, the cost of care is added to the losses of earnings. This technique however does not value the psychic costs of ill health. Many people find such procedure of calculating the worth of human life highly unsatisfactorily because according to this criterion a large section of people would command a very low economic value, especially the old people, disabled and those unemployed or in poorly paid jobs.

Travel Cost Method

This method estimates the time and money that people are willing to spend on 'eco-trips', *i.e.*, visits to places of environmental value such as mountains, forests, lakes and parks. This method, however, severely underestimates the worth of the environmental assets and services because of its highly narrow focus. It only looks at the entertainment, recreational aspects of environmental assets. Environment constitutes the basic life support system; its total value consists of several components as discussed above. This approach ignores most of them.

Contingent Valuation

In this method, the value of environmental assets and services is assessed through public opinion surveys. People are directly asked their valuation of the

environment. They are asked how much thing is willing to pay to conserve the environments. There are problems, however, with approach. People often lack knowledge in that area; therefore their responses do not accurately reflect their concerns. Secondly, there is a general inherent problem with Survey method *i.e.*, the answer to a question very much depends on the way it is asked. If people realise that their answer will have effect on the decisions they may reply in strategic manner.

For example, if how much they are willing to pay is a hypothetical question (*i.e.*, no payments are involved), people will answer it in one way. On the other hand, if there is a probability that they may actually have to pay they will answer it in another way. In the later case, there would be a systematic underestimation of the value of the environment. If the understand that they do not have to pay, the polluter will pay, their responses are likely to overestimate the value of the environment.

If they are asked how much compensation they should be given for the environmental damages, they would certainly exaggerate the worth of the environment.

For these reasons, it is quite difficult to interpret the survey responses and come up with a figure which genuinely represents people's valuation of the worth of the environment. Investigators should try to frame questions in such a manner which induces individuals to respond not as interested parties but as disinterested observers, as people concerned with the public interest.

For example The study of university housing environment is one research area where theoretical and practical objectives have been successfully combined. Thus one may understand the components of environment at various levels *i.e.*, At the level of activities, at the level of processes and at the level of orientations.

2

Management of Environmental Law

Law should provide a framework for regulating use of the environment. Law is crucial for environmental management in a number of ways, aiding:

- Regulation of resource use;
- Protection of the environment and biodiversity;
- Mediation, conflict resolution and conciliation;
- Formulation of stable, unambiguous undertakings and agreements.

Environmental management may involve a number of resource situations, *e.g.*, individually-owned (private) resources; national resources; shared resources; open-access resources; common property resources; global resources. Some of these are better covered by law than others. There are different legal systems—for example, based on Roman Law, on customary laws, Islamic Law, the Code Napoleon—to name but a few. Some countries have legal systems that combine more than one of these, say indigenous and colonial era legislation, plus Islamic Law. Areas may be subject to state and federal laws and to secular and religious laws. In most countries statutory law is written by politicians and passed by national legislature; and common law is compiled by judges (with reference to past cases and prior statutory law).

Most legislation evolves in response to problems, so there is often delay between need and the establishment of satisfactory law. Without effective legislation, resource use, pollution control, conservation, and most fields of human activity are likely to fall into chaos and conflict. Law can encourage satisfactory performance, enable authorities to punish those who infringe environmental management legislation, or confiscate equipment that is misused or faulty, or close a company; it may also be possible for employees, bystanders

and product or service users to sue for damages if they are harmed. Some countries have been active in developing environmental management law, notably Sweden, The Netherlands, the USA, Canada, Australia and New Zealand. Some environmental laws are ancient: Indian rulers promulgated controls on hunting and forest felling centuries ago; the UK had local pollution control laws as early as the twelfth century AD, and passed nationally enforced pollution control legislation like the Alkali Act (1863) over a century ago.

Environmental management increasingly involves transboundary problems that reach beyond traditional sovereignty limits, issues of negligence, and the need for nations to co-operate. International law is evolving to address such issues, although it is difficult to develop and enforce. Often powerful MNCs or TNCs are involved in issues and these may prompt and drive forward innovation, not necessarily to the benefit of the environment or the public. Walker likened them to seventeenth-century city states that had insufficient public accountability. The problem is to ensure that changes are for the good of the environment and the greater common good, rather than just suiting a large company or more countries.

Most laws, whether civil or criminal, are corrective—punishing wrong-doers and deterring others from infringing rules and agreements or from causing nuisance or injury. In the main, therefore, legislation has not been very pre-emptive. Environmental managers must also be aware that there is little point in passing laws or making international agreements if there cannot be adequate enforcement.

Three things are especially important for environmental legislation:

1. The precautionary principle, which has evolved to deal with risks and uncertainties faced by environmental management. The meaning is still not firmly established by law. The principle implies that an ounce of prevention is worth a pound of cure—it does not prevent problems but may reduce their occurrence and helps ensure contingency plans are made. The application of this principle requires either cautious progress until a development can be judged 'innocent', or avoiding development until research indicates exactly what the risks are, and then proceeding to minimize them. Once a threat is identified, action should be taken to prevent or control damage even if there is uncertainty about whether the threat is real. Some environmental problems become impossible or costly to solve if there is delay, so waiting for research and legal proof is not costless.

   Some hold that the principle should be applied in situations where both the probability and cost of impacts are unknown. The principle was stressed in many of the decisions reached at the Rio Earth Summit in 1992. For example, it was endorsed by Article 15 of the 1992 Rio Declaration on Environment and Development. Article 130r of the Maastricht Treaty (Treaty on European Union) of February 1992 states that EU policy on the environment shall be based on the precautionary principle.

2. The polluter-pays principle—in addition to the obvious—the polluter pays for damage caused by a development—this principle also implies that a polluter pays for monitoring and policing. A problem with this approach is that fines may bankrupt small businesses, yet be low enough for a large company to write them off as an occasional overhead, which does little for pollution control. There is debate as to whether the principle should be retrospective—*e.g.*, today a purchaser who acquires contaminated land in good faith is often forced to clean up the mess others left (if the polluter pays, how long back does liability stretch?). Developing countries are seeking to have developed countries pay more for carbon dioxide controls, arguing that they polluted the world during the Industrial Revolution, yet enjoy the fruits of invention from that era.
   The polluter-pays principle is more a way of allocating costs to the polluter than a legal principle. OECD member countries adopted the principle in 1972, at least in theory.
3. Freedom of information—if the public, NGOs ('green watchdogs') or even official bodies are unable to get information, environmental planning and management is hindered. Democracies have begun to release more information—the USA has a Freedom of Information Act, the EU is moving in that direction, and in the UK the (1994) Environmental Protection Act has helped. Few countries have such well-developed disclosure as the USA, which requires public registers of development activities, publication of Environmental Impact Statements, hazard warning on products, *etc.* Some governments and multinational corporations fear industrial secrets will leak to competitors if there is too much disclosure, and there are situations where authorities declare 'strategic' needs and suspend disclosure.
   In many countries, court actions, even if they were fought in the public interest, had to be brought by an individual, who, if they lost, paid costs. This acted as a deterrent for anyone to tackle government or large company wrongdoings, because they lacked equivalent resources. It is desirable that NGOs and individuals be allowed to bring legal actions to protect the environment, if need be as group cases (class actions). In the USA the Environmental Defence Fund, the Sierra Club, and environmental lawyers like Joseph Sax managed to achieve the right to bring class actions (or group actions) in the 1970s. Subsequently Canada, the UK and several other countries saw similar legal changes.

INTERNATIONAL LAW AND ENVIRONMENTAL MANAGEMENT

International law governs relations between states, and has no direct effect on domestic law or individuals. It is often difficult to force a sovereign state to sign, and then honour, a treaty or similar agreement. International law must

thus depend a great deal on voluntary agreements by governments and international bodies (the Brussels and Lugano Conventions on Environmental Law cover this issue of ensuring compliance). When negotiation fails a possibility is to refer the case to the International Court of Justice (not a very friendly process), or set up an International Joint Commission. International law has tended to be laissez-faire and ad hoc. From the mid-nineteenth century until the 1950s co-operation, exchange of information, agreement and international guidelines or rules were often initiated by international public unions, *e.g.*, the International Postal Union, or the International Telegraphic Union. Nowadays, the UN and its 15 specialist agencies (the FAO, WHO, UNESCO, UNEP, *etc.*) often initiate the development of international environmental law. For example, the UNEP has published guidelines on principles of conduct over shared natural resources (1978) and, more recently, on exchange of information on chemicals in international trade. NGOs like Greenpeace, Friends of the Earth and the World-Wide Fund for Nature also lobby for environmental legislation.

Various observers note the UN-supported system of environmental treaty making is valuable, although it needs strengthening—*e.g.*, the UN General Assembly can only recommend, not insist that law be made. Developing countries have complained that international law is too US- or Eurocentric and there is a wish in some countries to see more application of Islamic Law. Since the 1972 UN Conference on the Human Environment (Stockholm), most of the UN-prompted multilateral treaties have been developed by a two-step process: a relatively vague framework convention which acknowledges a problem is presented (most countries are happy to sign such a non-binding agreement); that step prompts action, especially data collection, discussion and propaganda, which reduces opposition and raises interest so that a protocol can be introduced and agreed to.

International law faces a number of challenges. One of the greatest is the management of 'global commons': oceans and their resources; world weather and climate; atmosphere; stratospheric ozone; space, *etc.* Many resources, and also pests, migrate or move, so that effective management of ocean fisheries, migratory fish in rivers, whaling, disease or locust control, *etc.*, needs to be through multilateral agreement. In the late 1970s a class action by an NGO forced the US Agency for International Development (USAID) to insist on pre-development environmental assessments before granting funds. In effect the precautionary principle embodied in NEPA was extended to the Third World with respect to aid. Within a few years most aid agencies had adopted environmental guidelines and rules. The end of the Cold War may mean more opportunities and resources for international environmental law to develop.

Indigenous Peoples and Environmental Law

IUCN estimates suggest there are over 250 million indigenous peoples who interact with environmental law with respect to:

1. Protection of natural environment together with indigenous people;
2. Rights of indigenous people over natural resources;

3. Rights over traditional knowledge—*e.g.*, to prevent ethnobotany becoming 'biopiracy' (gathering indigenous knowledge which is patented and sold);
4. Damages to indigenous people for past environmental wrongs by 'outsiders';
5. Views of indigenous people which could be fed into environmental law making.

Indigenous people often retain knowledge, skills and beliefs that relate closely to the natural environment. The protection of the environment is often vital to their physical and cultural survival, and they have insight which may aid environmental management and law making.

The rights of indigenous peoples are recognized by the UN Commission on Economic Development 1992 Convention on Biological Diversity and by the 1994 Draft UN Declaration of the Rights of Indigenous Peoples. Nevertheless, indigenous people often still have no written land tenure, making them vulnerable to abuse or resettlement if there are natural resources to be exploited.

In recent decades several countries have made changes to improve indigenous peoples' control of their environment and natural resources. Whether this will lead to better environmental management is debated. In Australia, New Zealand, the USA, Canada and Amazonian Brazil aboriginal people have fought for their sovereign rights to control and manage, or at least share in, resources.

In Australia debate about aboriginal territorial rights has become heated recently. The Australian High Court has ruled that Australia's indigenous people enjoy native title and access rights to land leased by Euro-Australian farmers, which means two land-users should legally coexist. An Aboriginal claim to coastal waters and the Great Barrier Reef, if awarded, would have considerable impact on fishing and coastal resorts.

A question increasingly asked is: who should bear the cost of rehabilitation after resources exploitation? For example, the Pacific island of Nauru, now independent, provided phosphates for some 90 years. Does it have any claim on past colonial powers to remedy damage? Nauru claimed through the International Court of Justice for damage done before its independence in 1967. Similar retrospective actions have arisen in Australia and in other Pacific islands, over nuclear weapons test sites, and in Papua New Guinea concerning mining.

BUSINESS ORGANISATIONS: THE INTERNAL ENVIRONMENT

The internal features of business organisations have received considerable attention by scholars of organisation and management, and a large number of texts have been devoted to this aspect of business studies. The aim is to focus on three areas of the internal organisation that relate directly to a study of the business environment: approaches to understanding organisations, organisation structures, and key functions within the enterprise. Further insight into these aspects and into management and organisational behaviour generally can be

gained by consulting the many specialist books in this field, a number of which are mentioned at the end of this stage. A central theme running through any analysis of the internal environment is the idea of 'management', which has been subjected to a wide variety of definitions. As used in this context, management is seen both as a system of roles fulfilled by individuals who manage the organisation and as a process which enables an organisation to achieve its objectives. The essential point is that management should be seen as a function of organisations, rather than as a controlling element, and its task is to enable the organisation to identify and achieve its objectives and to adapt to change. Managers need to integrate the various influences on the organisation–including people, technology, systems and the environment–in a manner best designed to meet the needs of the enterprise at the time in question and be prepared to institute change as and when circumstances dictate.

APPROACHES TO ORGANISATION AND MANAGEMENT

An important insight into the principles which are felt to underlie the process of management can be gained by a brief examination of organisational theories. These theories or approaches–some of which date back to the late nineteenth century–represent the views of both practising managers and academics as to the factors that determine organisational effectiveness and the influences on individuals and groups within the work environment. Broadly speaking, these approaches can be broken down into three main categories: the classical approach, the human relations approach, and the systems approach.

The Classical Approach

Classical theories of organisation and management mostly date from the first half of the twentieth century and are associated with the work of writers such as Taylor, Fayol, Urwick and Brech. In essence, the classicists basically viewed organisations as formal structures established to achieve a particular number of objectives under the direction of management. By identifying a set of principles to guide managers in the design of the organisational structure, the proponents of the classical view believed that organisations would be able to achieve their objectives more effectively. Fayol, for example, identified fourteen principles which included the division of work, the scalar chain, centralisation and the unity of command–features which also found expression in Weber's notion of 'bureaucracy'.

Urwick's rules or principles similarly emphasised aspects of organisation structure and operations–such as specialisation, co-ordination, authority, responsibility and the span of control–and were presented essentially as a code of good management practice. Within the classical approach special attention is often given to two important sub-groupings, known as 'scientific management' and 'bureaucracy'.

The former is associated with the pioneering work of F. W. Taylor who believed that scientific methods could be attached to the design of work so that

productivity could be increased. For Taylor, the systematic analysis of jobs was seen as the key to finding the best way to perform a particular task and thereby of achieving significant productivity gains from individuals which would earn them increased financial rewards. In Taylor's view, the responsibility for the institution of a scientific approach lay with management, under whose control and direction the workers would operate to the mutual benefit of all concerned. The second sub-group, bureaucracy, draws heavily on the work of Max Weber whose studies of authority structures highlighted the importance of 'office' and 'rules' in the operation of organisations.

According to Weber, bureaucracy–with its system of rules and procedures, specified spheres of competence, hierarchical organisation of offices, appointment based on merit, high level of specialisation and impersonality–possessed a degree of technical superiority over other forms of organisation, and this explained why an increasing number of enterprises were becoming bureaucratic in structure. Over 50 years after Weber's studies were first published in English, bureaucratic organisation remains a key feature of many enterprises throughout the world and is clearly linked to increasing organisational size and complexity. Notwithstanding the many valid criticisms of Weber's work, it is difficult to imagine how it could be otherwise.

The Human Relations Approach

Whereas the classical approach focuses largely on structure and on the formal organisation, the human relations approach to management emphasises the importance of people in the work situation and the influence of social and psychological factors in shaping organisational behaviour. Human relations theorists have primarily been concerned with issues such as individual motivation, leadership, communications and group dynamics and have stressed the significance of the informal pattern of relationships which exist within the formal structure. The factors influencing human behaviour have accordingly been portrayed as a key to achieving greater organisational effectiveness, thus elevating the 'management of people' to a prime position in the determination of managerial strategies. The early work in this field is associated with Elton Mayo and with the famous Hawthorne Experiments, conducted at the Western Electric Company between 1924 and 1932. What these experiments basically showed was that individuals at work were members of informal as well as formal groups and that group influences were fundamental to explaining individual behaviour.

Later work by writers such as Maslow, McGregor, Argyris, Likert and Herzberg continued to stress the importance of the human factor in determining organisational effectiveness, but tended to adopt a more psychological orientation, as exemplified by Maslow's 'hierarchy of needs' and McGregor's 'Theory X and Theory Y'. Maslow's central proposition was that individuals seek to satisfy specific groups of needs, ranging from basic physiological requirements, through safety, love and esteem, to self-actualisation; progressing

systematically up the hierarchy as each lower-level need is satisfied. To McGregor individuals at work were seen by management as either inherently lazy or committed to the organisation's objectives and often actively seeking responsibility. These perceptions consequently provided the basis for different styles of management, which ranged from the coercive to the supportive.

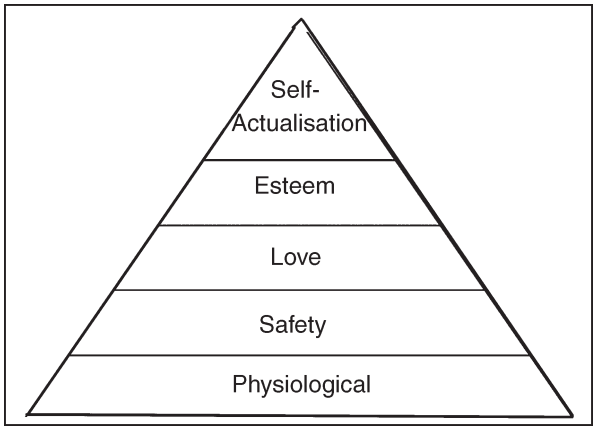


Fig. A Hierarchy of Needs.

McGregor's concern with management styles is reflected in later studies, including Ouichi's notion of 'Theory Z'. According to Ouichi one of the key factors in the success of Japanese manufacturing industries was their approach to the management of people.

Theory Z organisations were those which offered workers long-term employment, a share in decision making, opportunities for training, development and promotion, and a number of other advantages which gave them a positive orientation towards the organisation. For Ouichi, the key to organisational effectiveness lay in the development of a Japanese-style Theory Z environment, adapted to western requirements.

The Systems Approach

More recent approaches to organisation and management have helped to integrate previous work on structures, people and technology, by portraying organisations as socio-technical systems interacting with their environment. Under this approach–which became popular in the 1960s–organisations were seen as complex systems of people, tasks and technologies that were part of and interacted with a larger environment, comprising a wide range of influences. This environment was frequently subject to fluctuations, which on occasions could become turbulent.

For organisations to survive and prosper, adaptation to environmental demands was seen as a necessary requirement and one which was central to the process of management. Organisations, including those involved in business, are open systems, interacting with their environment as they convert inputs into output. Inputs include people, finance, materials and information, provided by

the environment in which the organisation exists and operates. Output comprises such items as goods and services, information, ideas and waste, discharged into the environment for consumption by 'end' or 'intermediate' users and in some cases representing inputs used by other organisations. Systems invariably comprise a number of sub-systems through which the process of conversion or transformation occurs.

Business organisations, for example, usually have sub-systems which deal with activities such as production, marketing, accounting and human resource management and each of these in turn may involve smaller sub-systems which collectively constitute the whole. Just as the organisation as a system interacts with its environment, so do the sub-systems and their component elements, which also interact with each other. In the case of the latter, the boundary between sub-systems is usually known as an 'interface'. While the obvious complexities of the systems approach need not be discussed, it is important to emphasise that most modern views of organisations draw heavily on the work in this area, paying particular attention to the interactions between people, technology, structure and environment and to the key role of management in directing the organisation's activities towards the achievement of its goals. Broadly speaking, management is seen as a critical sub-system within the total organisation, responsible for the co-ordination of the other sub-systems and for ensuring that internal and external relationships are managed effectively.

As changes occur in one part of the system these will induce changes elsewhere and this will require a management response that will have implications for the organisation and for its sub-systems.

Such changes may be either the cause or effect of changes in the relationship between the organisation and its environment, and the requirement for managers is to adapt to the new conditions without reducing the organisation's effectiveness. Given the complex nature of organisations and the environments in which they operate, a number of writers have suggested a 'contingency approach' to organisational design and management.

In essence, this approach argues that there is no single form of organisation best suited to all situations and that the most appropriate organisational structure and system of management is dependent upon the contingencies of the situation for each organisation. In some cases a bureaucratic structure might be the best way to operate, while in others much looser and more organic methods of organisation might be more effective. In short, issues of organisational design and management depend on choosing the best combination in the light of the relevant situational variables; this might mean different structures and styles coexisting within an organisation.

ORGANISATION STRUCTURES

Apart from the very simplest form of enterprise in which one individual carries out all tasks and responsibilities, business organisations are characterised by a division of labour which allows employees to specialise in particular roles

and to occupy designated positions in pursuit of the organisation's objectives. The resulting pattern of relationships between individuals and roles constitutes what is known as the organisation's structure and represents the means by which the purpose and work of the enterprise is carried out. It also provides a framework through which communications can occur and within which the processes of management can be applied. Responsibility for establishing the formal structure of the organisation lies with management and a variety of options is available. Whatever form is chosen, the basic need is to identify a structure which will best sustain the success of the enterprise and will permit the achievement of a number of important objectives.

Through its structure an organisation should be able to:

- Achieve efficiency in the utilisation of resources;
- Provide opportunities for monitoring organisational performance;
- Ensure the accountability of individuals;
- Guarantee co-ordination between the different parts of the enterprise;
- Provide an efficient and effective means of organisational communication;
- Create job satisfaction, including opportunities for progression; and
- Adapt to changing circumstances brought about by internal or external developments.
- In short, structure is not an end in itself, but a means to an end and should ideally
- Reflect the needs of the organisation within its existing context and taking into
- Account its future requirements.

In short, structure is not an end in itself, but a means to an end and should ideally reflect the needs of the organisation within its existing context and taking into account its future requirements. The essence of structure is the division of work between individuals and the formal organisational relationships that are created between them. These relationships will be reflected not only in individual job descriptions, but also in the overall organisation chart which designates the formal pattern of role relationships, and the interactions between roles and the individuals occupying those roles.

Individual authority relationships can be classified as line, staff, functional and lateral and arise from the defined pattern of responsibilities, as follows:

- *Line relationships* occur when authority flows vertically downward through the structure from superior to subordinate.
- *Staff relationships* are created when senior personnel appoint assistants who normally have no authority over other staff but act as an extension of their superior.
- *Functional relationships* are those between specialists and line managers and their subordinates. The personnel or computing function may be one such service that creates a functional relationship.
- *Lateral relationships* exist across the organisation, particularly between individuals occupying equivalent positions within different departments or sections.

With regard to the division of work and the grouping of organisational activities, this can occur in a variety of ways.

These include:

- *By function or major purpose*, associated particularly with departmental structures.
- *By product or service*, where individuals responsible for a particular product or service are grouped together.
- *By location*, based on geographical criteria.
- *By common processes*.
- *By client group*.

In some organisations a particular method of grouping will predominate; in others there will tend to be a variety of types and each has its own particular advantages and disadvantages. Attention is focused on five main methods of grouping activities in business organisations. Students should attempt to discover what types of structure exist within their own educational institution and the logic which underlies the choices made.

Functional Organisation

The functional approach to organisation is depicted in Figure. As its name indicates, in this type of structure activities are clustered together by common purpose or function. All marketing activities, for example, are grouped together as a common function, typically within a marketing department. Similarly, other areas of activity, such as production, finance, personnel and research and development, have their own specialised sections or departments, responsible for all the tasks required of that function.

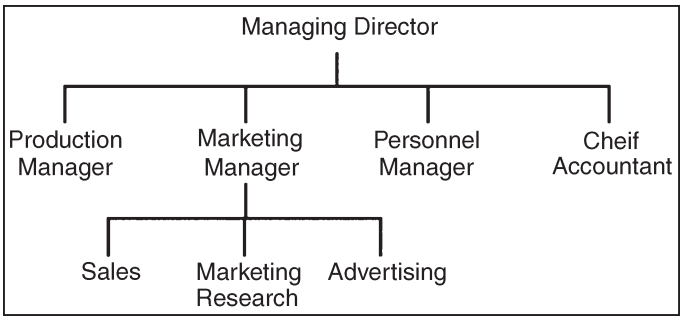


Fig. A Functional Organisation Structure.

Apart from its obvious simplicity, the functional organisation structure allows individuals to be grouped together on the basis of their specialisms and technical expertise, and this can facilitate the development of the function they offer as well as providing a recognised path for promotion and career development. On the downside, functional specialisation, particularly through departments, is likely to create sectional interests which may operate to the disadvantage of the organisation as a whole, particularly where inequalities in resource allocation between functions become a cause for interfunction rivalry.

It could also be argued that this form of structure is most suited to single-product firms and that it becomes less appropriate as organisations diversify their products and/or markets. In such circumstances, the tendency will be for businesses to look for the benefits which can arise from specialisation by product or from the divisionalisation of the enterprise.

Organisation by Product or Service

In this case the division of work and the grouping of activities is dictated by the product or service provided, such that each group responsible for a particular part of the output of the organisation may have its own specialist in the different functional areas. One advantage of this type of structure is that it allows an organisation to offer a diversified range of products, as exemplified by the different services available in National Health Service hospitals. Its main disadvantage is the danger that the separate units or divisions within the enterprise may attempt to become too autonomous, even at the expense of other parts of the organisation, and this can present management with problems of co-ordination and control.

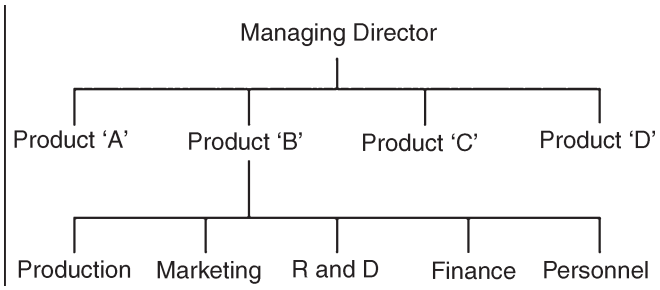


Fig. A Product-based Structure.

The Divisional Structure

As firms diversify their products and/or markets–often as a result of merger or takeover–a structure is needed to co-ordinate and control the different parts of the organisation. This structure is likely to be the divisional company. A divisionalised structure is formed when an organisation is split up into a number of self-contained business units, each of which operates as a profit centre. Such a division may occur on the basis of product or market or a combination of the two, with each unit tending to operate along functional or product lines, but with certain key functions provided centrally, usually at company headquarters. The main benefit of the multi-divisional company is that it allows each part of what can be a very diverse organisation to operate semi-independently in producing and marketing its products, thus permitting each division to design its offering to suit local market conditions–a factor of prime importance where the firm operates on a multinational basis. The dual existence of divisional profit centres and a central unit responsible for establishing strategy at a global level can, however, be a source of considerable tension, particularly where the needs and aims of the centre appear to conflict with operations at the local level or to impose burdens seen to be unreasonable by divisional managers.

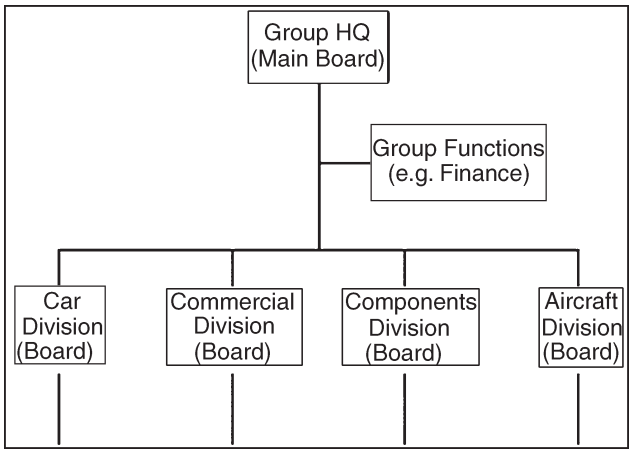


Fig. A Divisional Structure.

Much the same kind of arguments apply to the holding company, though this tends to be a much looser structure for managing diverse organisations, favoured by both UK and Japanese companies. Under this arrangement, the different elements of the organisation are co-ordinated and controlled by a parent body, which may be just a financial entity established to maintain or gain control of other trading companies. Holding companies are associated with the growth of firms by acquisition which gives rise to a high degree of product or market diversification. They are also a popular means of operating a multinational organisation.

Matrix Structures

A matrix is an arrangement for combining functional specialisation with structures built around products, projects or programmes. The resulting grid has a two-way flow of authority and responsibility. Within the functional elements, the flow is vertically down the line from superior to subordinate and this creates a degree of stability and certainty for the individuals located within the department or unit. Simultaneously, as a member of a project group or product team, an individual is normally answerable horizontally to the project manager whose responsibility is to oversee the successful completion of the project, which in some cases may be of very limited duration.

Matrix structures offer various advantages, most notably flexibility, opportunities for staff development, an enhanced sense of ownership of a project or programme, customer orientation and the co-ordination of information and expertise. On the negative side, difficulties can include problems of co-ordination and control, conflicting loyalties for staff and uncertain lines of authority. It is not uncommon in an organisation designed on matrix lines for project or programme leaders to be unsure of their authority over the staff from the contributing departments. Nor is it unknown for functional managers to withdraw their co-operation and/or support for projects located outside their immediate sphere of influence.

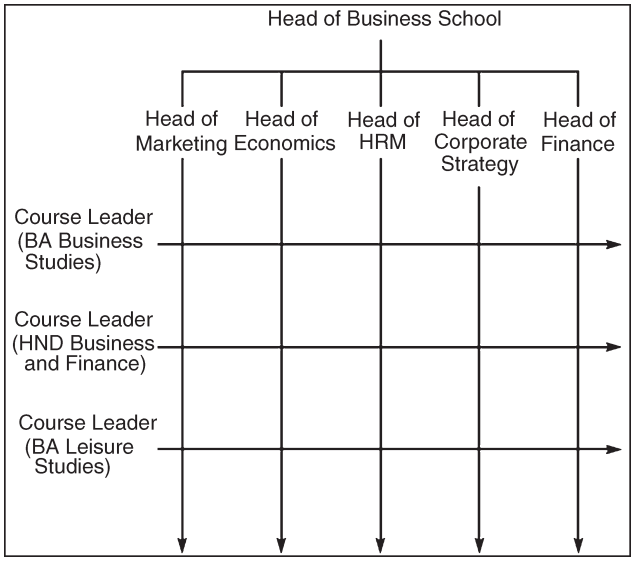


Fig. A Matrix Structure in a Business School

Project Teams

Despite its flexibility, the matrix often has a degree of permanence; in contrast, the project team is essentially a temporary structure established as a means of carrying out a particular task, often in a highly unstable environment. Once the task is complete, the team is disbanded and individuals return to their usual departments or are assigned to a new project. Fashioned around technical expertise rather than managerial rank and often operating closely with clients, project teams are increasingly common in high-technology firms, construction companies and in some types of service industry, especially management consultancies and advertising. Rather than being a replacement for the existing structure, they operate alongside it and utilise in-house staff on a project-by-project basis. While this can present logistical and scheduling problems and may involve some duplication of resources, it can assist an organisation in adapting to change and uncertainty and in providing products to the customer's specifications. Project teams tend to be at their most effective when objectives and tasks are well defined, when the client is clear as to the desired outcome and when the team is chosen with care.

THE VIRTUAL ORGANISATION

As indicated traditional organisations have structures which are designed to facilitate the transformation of inputs into output. Increasingly as the business environment changes, relationships both within and between organisations have needed to become more flexible and this has given rise to such developments as the growth in teleworking and the establishment of dynamic broker/agent networks involving considerable outsourcing of sub-tasks to 'agents' by the

core organisation. It is fair to say that this demand for greater flexibility has been driven partly by the market and partly by cost considerations and the process of change has been facilitated by relatively rapid developments in information technology. One area currently exciting the interest of writers on management and organisation is the concept of the virtual organisation, arguably the ultimate form of organisational flexibility. In essence a virtual organisation or firm signifies an extremely loose web of essentially freelance individuals or businesses who organise themselves to produce a specific customer product. Without any permanent structure or hierarchy this so-called firm can constantly change its shape and, despite existing across space and time, tends to appear edgeless, with its inputs, outputs and employees increasingly dispersed across the linked world of information systems. Given modern forms of communication, the potential exists for a totally electronic-based organisation trading in expertise and information with no real-world physical identity. This stands in stark contrast to the traditional view of the firm as an arrangement which adds value by transforming basic economic inputs into physical outputs or services.

STRUCTURAL CHANGE

Internal change is an important feature of the modern business organisation. In order to remain competitive and meet stakeholder needs, a firm may have to find ways to restructure its organisation as the environment in which it operates changes. Solutions can range from a partial or wholesale shift in the organisation's structural form to strategies for reducing the overall size and shape of the company or a radical redesign of business processes. Whereas business re-engineering normally connotes a root-and-branch reform of the way in which the business operates, downsizing essentially involves shrinking the organisation to make it 'leaner' and 'fitter' and hopefully more 'flexible' in its response to the marketplace. For some companies this means little more than reducing the size of the workforce through natural wastage and/or redundancies, as and when opportunities arise; for others it involves 'delayering' the organisation by removing a tier, or tiers, of management, thus effectively flattening the organisation's hierarchy and helping it to reduce its unit costs of production. In its most systematic and long-term form, downsizing can be used as a vehicle for cultural change through which an organisation's employees are encouraged to embrace notions of continuous improvement and innovation, and to accept that structural reform is a permanent and natural state of affairs. Under such an approach, retraining and reskilling become vital tools in implementing the chosen strategy and in shaping the organisation to meet the demands of its changing environment.

The danger is, however, that a firm may become too concerned with restructuring as a cure for all its problems, when the real cause of its difficulties lies in its marketplace. Cutting the number of employees, in such a situation, is unlikely to make unattractive products attractive; nor is it likely to boost morale within the organisation.

ASPECTS OF FUNCTIONAL MANAGEMENT

Most organisation structures reflect a degree of functional specialisation, with individuals occupying roles in departments, units or sections which have titles such as Production, Finance, Marketing, Personnel and Research and Development. These functional areas of the internal organisation, and the individuals who are allocated to them, are central to the process of transforming organisational inputs into output. The management of these functions and of the relationships between them will be a key factor in the success of the enterprise and in its ability to respond to external demands for change.

The interdependence of the internal functions can be demonstrated by a simple example. Providing goods and services to meet the market's needs often involves research and development which necessitates a financial input, usually from the capital market or the organisation's own resources. It also requires, as do all the other functions, the recruitment of staff of the right quality, a task which is more often than not the responsibility of the Personnel department. If research and development activities lead to a good idea which the Marketing department is able to sell, then the Production department is required to produce it in the right quantities, to the right specifications and at the time the market needs it. This depends not only on internal scheduling procedures within the Production department, but also on having the right kind of materials supplied on time by the Purchasing department, an appropriate system of quality control and work monitoring, machinery that is working and regularly serviced, the finished items packed, despatched and delivered and a multitude of other activities, all operating towards the same end.

The extent to which all of these requirements can be met simultaneously depends not only on internal factors, many of which are controllable, but also on a host of external influences, the majority of which tend to be beyond the organisation's control.

To demonstrate this interface between the internal and external environments, two key areas of functional management are discussed briefly–marketing and human resource management. An examination of the other functions within the organisation would yield very similar findings.

Human Resource Management

People are the key organisational resource; without them organisations would not exist or function. All businesses need to plan for and manage the people they employ if they are to use this resource effectively and efficiently in pursuit of their objectives. In modern and forward-looking organisations this implies a proactive approach to the management of people which goes beyond the bounds of traditional personnel management and involves the establishment of systems for planning, monitoring, appraisal and evaluation, training and development and for integrating the internal needs of the organisation with the external demands of the marketplace.

Such an approach is associated with the idea of human resource management. As in other areas of management, HRM involves a wide variety of activities related to the formulation and implementation of appropriate organisational policies, the provision of opportunities for monitoring, evaluation and change, and the application of resources to the fulfilment of organisational ends.

Key aspects of 'people management' include:

- Recruitment and selection;
- Working conditions;
- Training and career development;
- Job evaluation;
- Employee relations;
- Manpower planning; and
- Legal aspects of employment.

In most, if not all, cases these will be affected by both internal and external influences, some of which will vary over time as well as between organisations. The provision of these activities within an organisation can occur in a variety of ways and to different degrees of sophistication. Some very small firms may have little in the way of a recognisable HRM function, being concerned primarily with questions of hiring and firing, pay and other working conditions, but not with notions of career development, staff appraisal or job enrichment.

In contrast, very large companies may have a specialist HRM or Personnel department, often organised on functional lines and responsible for the formulation and implementation of personnel policies throughout the organisation. Such centralisation provides not only some economies of scale, but also a degree of standardisation and consistency across departments. To allow for flexibility, centralised systems are often combined with an element of decentralisation which permits individual departments or sections to exercise some influence in matters such as the recruitment and selection of staff, working conditions, training and career development. To illustrate how the different aspects of HRM are influenced by external factors, one part of this function–recruitment and selection of staff–has been chosen.

This is the activity within the organisation which seeks to ensure that it has the right quantity and quality of labour in the right place and at the right time to meet its requirements at all levels. To achieve this aim, the organisation initially needs to consider a large number of factors, including possible changes in the demand for labour, the need for new skills and likely labour turnover, before the processes of recruitment and selection can begin. These aspects in turn will be conditioned by a variety of factors such as changes in the demand for the product, the introduction of new technology and social, economic and demographic changes, some of which may not be anticipated or expected by strategic planners. Once recruitment and selection is ready to begin, a further raft of influences will impinge upon the process, some of which emanate from external sources.

In drawing up a job specification, for example, attention will normally need to be paid to the state of the local labour market, including skill availability,

competition from other employers, wage rates in comparable jobs and/or organisations, and sociodemographic trends. If the quality of labour required is in short supply, an organisation may find itself having to offer improved pay and working conditions simply to attract a sufficient number of applicants to fill the vacancies on offer.

Equally, in fashioning its job advertisements and in drawing up the material it sends out to potential applicants, a firm will need to pay due attention to the needs of current legislation in areas such as equal opportunities, race discrimination and employment protection, if it is not to infringe the law.

Among the other external factors the enterprise may need to take into consideration in recruiting and selecting staff will be:

- The relative cost and effectiveness of the different advertising media;
- Existing relationships with external sources of recruitment;
- Commitments to the local community;
- Relationships with employee organisations; and
- Opportunities for staff training and development in local training and educational institutions.

Ideally, it should also pay some attention to possible future changes in the technology of the workplace, in order to recruit individuals either with appropriate skills or who can be retrained relatively easily with a minimum amount of disruption and expense to the organisation.

The Marketing Function

The processes of human resource management provide a good illustration of the interactions between a firm's internal and external environments. An even better example is provided by an examination of its marketing activities, which are directed primarily, though not exclusively, towards what is happening outside the organisation. Like 'management', the term 'marketing' has been defined in a wide variety of ways, ranging from Kotler's essentially economic notion of an activity directed at satisfying human needs and wants through exchange processes, to the more managerial definitions associated with bodies like the Chartered Institute of Marketing.

A common thread running through many of these definitions is the idea that marketing is concerned with meeting the needs of the consumer in a way which is profitable to the enterprise. Hence, strategic marketing management is normally characterised as the process of ensuring a good fit between the opportunities afforded by the marketplace and the abilities and resources of an organisation operating in it. This notion of marketing as an integrative function within the organisation–linking the needs of the consumer with the various functional areas of the firm–is central to modern definitions of the term and lies at the heart of what is known as the 'marketing concept'.

This is the idea that the customer is of prime importance to the organisation and that the most significant managerial task in any enterprise is first to identify the needs and wants of the consumer and then to ensure that its operations are

geared to meeting these requirements profitably. Though it would be true to say that not all organisations subscribe to this view, it is generally accepted that the successful businesses are predominantly those with a customer rather than a production or sales orientation. Equally, the evidence suggests that the need to adopt such a customer-centred approach applies not only to private sector trading organisations, but also increasingly to public sector enterprises and to bodies not established for the pursuit of profits but for other purposes. When viewed from a customer perspective, marketing can be seen to comprise a range of activities that go beyond the simple production of an item for sale.

These include:

- Identifying the needs of consumers.
- Designing different 'offerings' to meet the needs of different types of customers.
- Choosing products, prices, promotional techniques and distribution channels that are appropriate to a particular market.
- Undertaking market and product planning.
- Deciding on brand names, types of packages, and methods of communicating with the customer.
- Creating a marketing information system.

As already indicated, in carrying out these activities the firm is brought into contact with a range of external influences of both an immediate and indirect kind. This external marketing environment can have a fundamental impact on the degree to which the firm is able to develop and maintain successful transactions with its customers and hence on its profitability and chances of survival. To illustrate how a firm's marketing effort can be influenced by external factors, the following brief discussion focuses on 'pricing', which is one of the key elements of the 'marketing mix', that is, the set of controllable variables which a business can use to influence the buyer's response, namely, product, price, promotion and place–the 4Ps. Of all the mix elements, price is the only one which generates revenue, while the others result in expenditure. It is therefore a prime determinant of a firm's turnover and profitability and can have a considerable influence on the demand for its products and frequently for those of its competitors. Leaving aside the broader question of a firm's pricing goals and the fact that prices will tend to vary according to the stage a product has reached in its life cycle, price determination can be said to be influenced by a number of factors. Of these, the costs of production, the prices charged by one's competitors and the price sensitivity of consumers tend to be the most significant. In the case of cost-based pricing, this occurs when a firm relates its price to the cost of buying or producing the product, adding a profit margin or 'mark-up' to arrive at the final selling price. Such an approach tends to be common amongst smaller enterprises where costs are often easier to estimate and where likely consumer reactions are given less attention than the need to make an adequate return on the effort involved.

The essential point about this form of price determination is that many of the firm's costs are influenced by external organisations–including the suppliers of

materials, components and energy–and hence pricing will often vary according to changes in the prices of inputs. Only larger organisations, or a group of small businesses operating together, will generally be able to exercise some influence over input prices and even then not all costs will be controllable by the enterprise. Organisations which take an essentially cost-based approach to pricing will sometimes be influenced by the prices charged by competitors–particularly in markets where considerable competition exists and where the products are largely homogeneous and a buyer's market is evident. The competitive approach to pricing, however, is also found in markets where only a few large firms operate and where the need to increase or maintain market share can give rise to virtually identical prices and to fierce non-price competition between the market leaders.

In Britain, for instance, a big cross-Channel ferry operator will normally provide the service to customers at the same price as its rivals, differentiating its offering in terms of additional benefits rather than price. Where this is the case, the external demands of the market rather than costs constitute the primary influence on a firm's decisions, and changes in market conditions will tend to be reflected in price changes. This idea of market factors influencing pricing decisions also applies to situations where firms fix their prices according to the actual or anticipated reactions of consumers to the price charged for a product–known in economics as the price elasticity of demand. In this case, the customer rather than a firm's competitors is the chief influence on price determination, although the two are often interrelated in that consumers are usually more price sensitive in markets where some choice exists.

Differential levels of price sensitivity between consumers of a product normally arise when a market has distinct segments based on factors such as differences in income or age or location. In such cases a firm will often fix its prices according to the segment of the market it is serving, a process known as 'price discrimination' and one which is familiar to students claiming concessionary fares on public transport. While the discussion has been oversimplified and does not take into account factors such as the price of other products in an organisation's product portfolio, it illustrates quite clearly how even one of the so-called controllable variables in a firm's marketing mix is subject to a range of external influences that are often beyond its ability to control.

The same argument applies to the other elements of the marketing function and students could usefully add to their understanding of the internal/external interface by examining how the external environment impinges upon such marketing activities as promotion, distribution or market research.

UN CONFERENCE ON ENVIRONMENT AND DEVELOPMENT

Sometimes referred to as the 'Earth Summit' or abbreviated to UNCED, held in 1992 the Rio Conference was a test of the ability of the international political and legal order to reach a consensus for the good of the whole world.

Originally there were hopes that UNCED would agree an Earth Charter, but this was not achieved, although several new declarations were made and conventions were established. Freestone reviewed the implications of UNCED, stressing that it did crystallize principles which contribute to the development of international environmental law. However, some feel the Earth Summit tended to weaken international environmental law by focusing on development issues. A follow-up meeting to UNCED, the Rio II Conference was held in New York in 1997.

Agreements made at the Earth Summit, 1992

- Rio Declaration on Environment and Development updated version of the Stockholm Declaration (of 1972); published general principles for future international action on environment and development.
- Framework Convention on Climate Change framework for negotiation of detailed protocols to deal with control of greenhouse gas emissions, deforestation, sea-level change, *etc.*
- Convention on Biological Diversity intended to arrest alarming rate of species loss (criticized for having been poorly and hurriedly drafted).
- Declaration on Forests a principle, not legally binding, this was substituted for original idea of a Forest Convention.
- Agenda 21 an action plan for the rest of the century and framework for dealing with environment and development issues. Consists of 40 chapters (not a legally binding instrument).
- Global Environmental Facility a fund established for global problem-solving. Under the auspices of the World Bank, UNEP and UNDP. Designed to be 'democratic and transparent' and helpful to poor nations. Amongst other things, intended to support Biodiversity and Climate Change Conventions.

International Law and Sovereignty Issues

Sovereignty affects access to data and monitoring, and can be a major constraint on environmental management. Countries are usually reluctant to sign any agreement which affects their sovereign powers. Yet growing transboundary and global environmental problems make it important to get co-operation. There are transnational and multinational corporations sufficiently powerful to threaten and bribe their way around sovereignty and other controls. Terrorism can have transnational or global impact, so there should be better international controls and co-operation to counter it. Unfortunately for many environmental management issues, getting multi-state agreements is a slow process.

In 1977 the Stockholm Declaration on the Human Environment affirmed the sovereign right of states to exploit their own resources and their responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment beyond the limits of their national jurisdiction. This

affirmation has had considerable influence on subsequent international environmental law making. International trade agreements, notably the GATT/WTO provisions, mean that if a country has environmental protection laws, say controlling the import of pesticide-contaminated produce, timber cut in an environmentally unsound fashion, or fish caught using nets that kill dolphins, these measures may be unenforceable because they impair 'free trade'. The level playing field demanded by trade agreements may make it difficult to control importation of food and commodities produced by means of genetic engineering and growth- or lactation-enhancing hormones.

Conversely, there may be situations where globalization helps countries adopt and enforce better standards (care must be taken to ensure that the motive is to improve environmental quality and not an attempt to make production costs uniform or create a global market for standardized products that enjoy economies of scale). Globalization of patent rights has generated concern; MNCs and TNCs seek to recoup research costs and control markets; poor countries fear bio-piracy with corporations patenting and claiming intellectual rights on genetic resources and ideas derived from such resources. The patenting and control of sales of crop seeds (modern varieties) and pharmaceutical products has also caused much friction.

Protection and extension of sovereignty can lead to wars; testing and storage of weapons; and territorial claims. These affect the environment and need to be more firmly addressed by international agreements and law. The pollution associated with the Gulf War underlines the importance of negotiation. Hostile environmental modification is covered by the 1977 Environmental Modification Convention (invoked to hold Iran to reparations for damage to Kuwait), and there are controls on nuclear, chemical and biological weapons.

A number of trends are apparent here. There has been a move towards the precautionary principle—since about 1972 countries have been guided to try to prevent pollution accidents and misdemeanours. Obtaining damages for, or penalizing, transnational pollution has been patchy, *e.g.*, there were no adjudications over Chernobyl, Amoco Cadiz and many similar disasters. There has been little progress in establishing 'environmental rights' (*i.e.*, rights of natural objects or organisms), although in some western countries there is a vociferous animal rights lobby.

Various agreements and conventions have reaffirmed and there are many areas agreed by scientists, social scientists and other specialists to be in need of formal protection. Protection may be supported by a state; privately funded by a group or individual; or by an international body or bodies. For example, there is a worldwide scatter of Biosphere Reserves; the UK has state-protected Sites of Special Scientific Interest (SSSIs); many countries have reserves and national parks. Some conservation areas are established and watched over by international treaty—the 1971 Ramsar Convention (Convention on Wetlands of International Importance) provides a framework for protection of wetland habitats, especially those used by migrating birds. The UN Educational, Scientific and Cultural Organization (UNESCO) supports and oversees many sites of special cultural value.

The Antarctic

In Antarctica territorial claims have been put aside (but not eliminated) under the Antarctic Treaty which came into force in 1960 (signed 1959). Basically this is an international treaty by which signatories have agreed to keep Antarctica and its surrounding seas open for scientific research by all nations deemed to be pursuing scientific exploration south of 60°S. The treaty requires demilitarization, no nuclear weapons and a commitment to conservation.

While it has been quite a flexible treaty, modified as need arose, it has been put under some pressure as interest in resource development (notably oil, minerals, krill, squid and fish) comes into conflict with its conservation requirements. There are also demands from non-treaty nations (basically those which have not maintained a significant research presence there) and some NGOs for there to be changes to give the whole world (probably through the UN), not just signatory nations, control of Antarctica (a coalition of over 200 NGOs and non-treaty nations—the Atlantic and Southern Ocean Coalition—has been seeking such a goal). There have been some moves which in theory could allow mineral resources to be used—the 1988 Convention on the Regulation of Antarctic Mineral Resource Activities allows exploitation only if very stringent environmental assessments are made and accepted by treaty nations. The Falklands conflict is a warning that if potentially attractive mineral resources are identified territorial claims may reappear in Antarctica.

Transboundary Pollution

In 1965 Canada and the USA became involved in the Trail Smelter pollution case. The outcome was acceptance that no state has the right to permit use of its territory in such a way as to injure another territory. The 1972 UN Conference on the Human Environment in Stockholm was in part called for by Sweden, because of concern about acid deposition generated by other countries. In 1979 the Geneva Convention on Long-Range Transboundary Air Pollution addressed the problem of transboundary sulphur dioxide atmospheric emissions, but did not lay down firm rules. By the late 1980s the resolution of transboundary impacts had become an increasingly active field of diplomacy. The 1991 UN Economic Commission for Europe Convention on Environmental Impact Assessment in a Transboundary Context obliged signatory states to act to control transboundary environmental impacts from proposed activities.

Controls on Global Warming

The UN Framework Convention on Climate Change obliged signatories to stabilize CO2 emissions at 1990 levels by AD 2000. The 1997 Kyoto Conference was intended to settle details of CO2 reduction and to see that targets were enforced by international law. However, a coalition of USA industries was opposed to any limit on greenhouse gas emissions, and lobbied to hinder agreements. Finally agreements were made by the EU to make an 8 per cent cut

in emissions by AD 2010 and arrangements for Tradeable Emissions Quotas (TEQs) were approved (with Russia able to sell its unused quotas to the USA).

Ozone Damage Controls

Efforts to phase out and if possible ban the use of CFCs were made at the 1985 Vienna Convention for the Protection of the Ozone Layer. The 1987 Montreal Protocol on Substances that Deplete the Ozone Layer—revised 1990—derives from the Vienna Convention. The protocol aimed for a 50 per cent cut in CFCs over a short period (24, mainly developed nations signed—by 1994 this had increased to 74, including some developing countries) and was signed in the face of considerable uncertainty about ozone damage. The protocol is a landmark, in that for the first time nations agreed to impose significant costs on their economies in order to protect the global environment. India and China held out, seeking agreement for funding to assist with ozone controls.

The Law of the Sea

In 1954 the International Convention for the Prevention of Pollution from Ships was undertaken to try to reduce the discharge of waste oil from oil-tankers and other ship-related discharges (with limited success). For ocean pollution control to be effective, agreements that cover rivers, effluent outfalls, air pollution, *etc.* are required, because pollutants arrive in the sea from such sources. In 1958 the First Conference on Law of the Sea took place (the second was in 1960), and in 1959 the UN established the International Maritime Organization to deal with marine safety, law, pollution control, *etc.*

From the early 1970s some of the nations with coastlines began to declare extensions of their territorial waters from the accepted 3 to 12, or even 200 nautical miles. The 1950 Continental Shelf Convention was largely behind this trend towards extension of exclusive sovereign rights to continental shelf or seabed resources. To try to formalize these trends the Third Conference on Law of the Sea was held in 1974.

The UNEP's Regional Seas Programme has brought together coastal states of a number of marine regions, resulting in several Regional Seas Treaties, covering: the Mediterranean; the Gulf; West Africa; Southeast Pacific; Red Sea; Caribbean; East Africa; and the South Pacific. These treaties led to the development of Environmental Action Plans and then co-ordination to fight pollution, *etc.* In 1977 the North Sea ceased to be 'high seas' as far as fish and mineral exploitation were concerned, when the EC established zones laying claim to the continental shelf. A number of the regional seas, *e.g.*, the North Sea, Japan's Inland Sea, the Baltic and the Mediterranean have been the subject of convention or treaty agreements in addition to the efforts of the UNEP to try to control pollution more effectively.

Meeting in Jamaica in 1982, the UN launched the Convention on the Law of the Sea (with agreements effective to 2500 m depth from the shore). Some developing countries are keen to see the oceans, like Antarctica, declared

common heritage, rather than becoming de facto possessions of those countries with the wealth and technology to exploit the resources. There has been some progress, *e.g.*: the EU is developing a form of supranational legislation, and the UNEP argues that international law should deal with protecting the world's life support systems.

Alternative Dispute Resolution

Disputes about resource exploitation and environmental management can be addressed in a number of ways:

1. Through legal measures (judicial);
2. Through political measures;
3. Through administrative measures;
4. Through alternative dispute resolution measures (which may not use law).

Legal measures rely upon courts, litigation, protocols and procedures, *etc.* Political measures rely upon elected or established representatives to decide. Administrative measures can be used to improve resources and environmental management.

Alternative dispute resolution can be through a range of measures, including:

- Negotiation;
- Mediation;
- Arbitration;
- Public consultation.

Environmental management legislation may specify the use of some of these measures, or they may be adopted voluntarily. Negotiation is a process whereby two or more groups agree to meet to explore solutions, in the hope of reaching consensus. Mediation is similar to negotiation, but involves a mutually accepted neutral third party who finds facts and tries to facilitate discussion. The mediator may act with groups that are unwilling to meet face to face, if need be 'filtering' the exchanges to help reach agreement. Arbitration involves a third party like mediation, but at the outset the parties involved agree to give the arbitrator power to make decisions (which may or may not be binding).

US NATIONAL ENVIRONMENTAL POLICY ACT (NEPA)

Discussions leading to NEPA began in the early 1960s, when the need was perceived for the USA to have a basic declaration of national environmental policy and an action-forcing provision. The US Government was largely reacting to public opinion that conventional planning did not adequately take account of the environment; it already had responsibility to steward resources and protect the environment under the Public Trust Doctrine. However, before NEPA the USA had little effective federal control over the environment and lacked land use regulations which some other countries had. NEPA was signed into US Law on 1 January 1970, to reform federal policy-making, and influence the

private sector to reorientate values. Originally it was intended that NEPA would change the nature of federal decision-making. However, it has become more of a procedural requirement. Caldwell —one of the architects of NEPA—felt that, had it not happened in the USA, something similar would have appeared elsewhere. NEPA required environmental impact assessment (EIA) prior to federally funded projects that might 'significantly' affect the environment—a message to officials to 'look before you leap'. NEPA Section 101 set regulations to protect the environment, Section 102 (2) (c) ensured they were pursued, and Section 103 included provision for EIA statements to be challenged in court.

That happened a lot at first because NEPA was untested and used expressions like 'significant' and 'human environment' that were poorly defined. There was also some need to clarify which developments required EIA, and how and by whom it was to be conducted. Virtually the world's first use of the expression 'EIA' occurs in Section 102 (2) c of NEPA, which requires US federal agencies to prepare an environmental impact statement (EIS) (bearing the costs against taxes, and sending copies to federal and state agencies and to the public) using EIA, prior to taking action.

There were three main elements in NEPA:

1. NEPA announced a US national policy for the environment.
2. It outlined procedures for achieving the objectives of that policy.
3. Provision was made for the establishment of a US Council on Environmental Quality (CEQ) which was to advise the US President on the environment, review the EIA process, review draft EISs, and see NEPA was followed. Also in 1970 the US Government created the US Environmental Protection Agency (EPA), its brief to co-ordinate the attack on environmental pollution and to be responsible for the EIA process (the EPA is in effect 'overseer' of impact assessment in the USA).

NEPA was the first time US Law had really allowed for development to be delayed or abandoned for the long-term good of the environment, and for efforts to be made to co-ordinate public, state, federal and local activities. Effectively, NEPA put environmental quality on a level with economic growth, a revolution in values in a country where state intrusion was anathema—for this reason many see it as a sort of Magna Carta, although it stopped short of making a healthy environment a Constitutional Right.

Public participation is written into NEPA to the extent it might be described as a corner-stone. NEPA is statutory law: it was written after deliberation, and did not evolve from custom, practice or tradition. Consequently, like a charter, it was imperfect; there were problems, especially delay, as litigation took place over various issues.

Many felt NEPA had been abducted by lawyers and could become a bureaucratic delaying tactic. These teething problems have largely been resolved, although some feel NEPA should be strengthened, possibly leading to changes in the US Constitution to better manage the environment. NEPA has been a

seminal concept and catalyst for EIA in other countries, although bodies like the Canadian Environmental Assessment Research Council and the International Association for Impact Analysis also deserve credit for spreading and developing mandatory development review processes. Effective implementation of EIA demands legislation and law enforcement to ensure that:

- There are no loopholes, so that no activity likely to cause impacts escapes EIA;
- The assessment is adequate;
- The assessment is heeded;
- The public are kept sufficiently informed or, ideally, involved in assessment.

European Law and Environmental Management

The European Community (EC) grew from the six original states which signed the Treaty of Rome in 1957 to form a closer European Union of 15 nations in 1995 which is set to expand further in the future. EU members like Sweden and The Netherlands have long-established traditions of environmental concern; others have given the environment far less attention. Growing EU integration should prompt and support better policies more widely. It will also ensure common rules and ways of monitoring, setting standards, *etc.* In 1992 the EU established a European Environmental Agency as a clearing-house for environmental information. Its role is also to evaluate and disseminate information and develop means for applying the precautionary principle, but not enforcement of environmental policy.

The Council of Europe had 35 EU and other member states in 1995 (many former colonies, trading partners, *etc.*), and is active in advocacy, cultural relations and raising awareness of issues including conservation and environmental protection. A UN agency that acts as a pan-European forum is the UN Commission for Europe (UNECE), which supports sustainable development, environmental research, and has launched or serviced several agreements dealing with issues like pollution (*e.g.*, the 1992 Convention on Transboundary Effects of Industrial Accidents). Environmental legislation is an important part of the emerging pan-European legal system (with the European Court of Justice as an overall arbitrator). The European Environmental Agency has not got as much enforcement power as the US Environmental Protection Agency, and serves mainly to gather information on the state of the European environment.

The EU has also established a European Environmental Information and Observation Network; a European Economic Community (EEC) Directive on Environmental Impact Assessment —which requires environmental assessment to be undertaken by developers; an EEC Directive on Freedom of Access to Information on the Environment —which requires authorities to ensure public access to relevant environmental information; and an EC Regulation on Eco-Management and Auditing (EMAS). One could make the broad generalization

that EU environmental law has focused on co-ordination, codification and integration. Since about 1973 there has been more interest in integrating wider environmental issues into politics alongside concern for achieving economic growth. In 1985 the European Commission decided environmental protection should be an integral part of economic and social policies at macroeconomic level and by sector. This was incorporated into the Treaty of Rome in 1987 and was strengthened by the Maastrict Treaty (1993), which included a statement of concern for sustainable growth. EU legislation seems to be increasingly aligning itself with global conventions such as those relating to global warming or waste management. Since 1993 EU law has been enacted to support more freedom of environmental information, better standard setting, the precautionary principle, and the polluter-pays principle; Winter has listed the core objectives:

- Preserve, protect and improve the quality of the environment.
- Protect human health.
- Prudent and rational use of natural resources.
- Promote measures at international level to deal with regional or world-wide environmental problems.

Hughes has noted that environmental management law should be 'vertically integrated' between regional, national and international systems. The EEC system allows this to some extent. Efforts to develop an overall EEC environmental policy resulted in the publication in 1973 of the First Programme of Action on the Environment; the Second, Third, Fourth and Fifth Action Programmes appeared in 1977, 1983, 1987, 1992 (reviewed in 1995), and lay down principles that EEC environmental legislation should adhere to. The Fifth Programme of Action on the European Environment seeks to incorporate good environmental policy into all Community policies. In the UK the 1995 Environment Act created a powerful, wide-ranging Environmental Agency for England and Wales, which brought together the functions previously spread among many agencies (pollution control, fisheries management, flood defence, *etc.*).

3

Mitigation and Management of Air Pollution Control

Section 19

Declaration of air pollution control area: 'The Act has provided for measures, which are:

a. Preventive in nature, in the case of industries to be established.
b. In the case of industries already established they are remedial.

The primary responsibility of controlling air pollution is on the Board. The very first measure to be adopted in the respect is the declaration of any area or areas within the State as air pollution control area.

The sub-section thus provides that the State Government may, after consultation with the State Board, by notification in the Official Gazette, declare in such manner as may be prescribed, any area or areas within the State as air pollution control area or areas for the purposes of the Act.

As regards power to give instructions for ensuring standards for emission from automobiles, Section 20 of the Act lays down that with a view to ensuring that the standards for emission of air pollutants from automobiles laid down by the State Board under clause (g) of sub-section(1) of Section 17 are complied with the State Government shall, in consultation with the State Board, give such instructions as may be deemed necessary to the concerned authority in charge of registration of motor vehicles under the Motor Vehicles Act, 1988, and such authority shall notwithstanding anything contained in that Act or the rules made there under be bound to comply with such instructions.

PENALTIES FOR VIOLATION OF VARIOUS PROVISIONS THE AIR ACT 1981

Section 37-: Failure to comply with the provisions of section 21 or section 22 or with the directions issued under section 31-A:

1. Whoever fails to comply with the provisions of section 21 or section 22 or directions issued under section 31-A, shall, in respect of each such failure, be punishable with imprisonment for a term which shall not be less than one year and six months but which may extend to six years and with fine, and in case the failure continues, with an additional fine which may extend to five thousand rupees for every day during which such failure continues after the conviction for the first such failure.
2. If the failure referred to in sub-section(l) continues beyond a period of one year after the date of conviction, the offender shall be punishable with imprisonment with a term which shall not be less than two years but which may extend to seven years and with fine.

Section 38-: Penalties for certain acts: Whoever:

a. Destroys, pulls down, removes, injures or defaces any pillar, post or stake fixed in the ground or any notice or other matter put up, inscribed or placed, by or under the authority of the Board.
b. Obstructs any person acting under the orders or directions of the Board from exercising his powers and performing his functions under this Act, or
c. Damages any works or property belonging to the Board, or
d. Fails to furnish to the Board or any officer or other employee of the Board any information required by the Board or such officer or other employee for the purpose of this Act, or
e. Fails to intimate the occurrence of the emission of air pollutants into the atmosphere in excess of the standards laid down by the State Board or the apprehension of such occurrence, to the State Board and other prescribed authorities or agencies as required under Sub-Section(l) of Section 23, or
f. In giving any information which he is required to give under this Act, makes a statement which is false in any material particular, or
g. For the purpose of obtaining any consent under Section 21, makes a statement which is false in any material particular, shall be punishable with imprisonment for a team which may extend to three months or with fine which may extend to (ten thousand rupees) or with both.

Section 39-: Penalty for contravention of certain provisions of the Act.

Whoever contravenes any of the provisions of this Act or any order or direction issued there under, for which no penalty has been elsewhere provided in this Act, shall be punishable with imprisonment for a team which may extend to three months or with fine which may extend to ten thousand rupees or with

both, and in the case of continuing contravention, with an additional fine which may extend to five thousand rupees for every day during which such contravention after conviction for the first such contravention.

Environment Protection Act

Important terms used in this act:

(a) "Environment" includes water, air and land and the inter- relationship which exists among and between water, air and land, and human beings, other living creatures, plants, micro-organism and property;

(b) "Environmental pollutant" means any solid, liquid or gaseous substance present in such concentration as may be, or tend to be, injurious to environment;

(c) "Environmental pollution" means the presence in the environment of any environmental pollutant;

General Powers of the Central Government:

(i) *Co-ordination of actions by the State Governments, officers and other authorities:*
   (a) Under this Act, or the rules made there under, or
   (b) Under any other law for the time being in force which is relatable to the objects of this Act

(ii) Planning and execution of a nation-wide programme for the prevention, control and abatement of environmental pollution.

(iii) Laying down standards for the quality of environment in its various aspects.

(iv) Laying down standards for emission or discharge of environmental pollutants from various sources whatsoever:
Provided that different standards for emission or discharge may be laid down under this clause from different sources having regard to the quality or composition of the emission or discharge of environmental pollutants from such sources.

(v) Restriction of areas in which any industries, operations or processes or class of industries, operations or processes shall not be carried out or shall be carried out subject to certain safeguards.

(vi) Laying down procedures and safeguards for the prevention of accidents which may cause environmental pollution and remedial measures for such accidents.

(vii) Laying down procedures and safeguards for the handling of hazardous substances.

(viii) Examination of such manufacturing processes, materials and substances as are likely to cause environmental pollution.

(ix) Carrying out and sponsoring investigations and research relating to problems of environmental pollution.

(x) Inspection of any premises, plant, equipment, machinery, manufacturing or other processes, materials or substances and giving, by order, of such

directions to such authorities, officers or persons as it may consider necessary to take steps for the prevention, control and abatement of environmental pollution;

(xi) Establishment or recognition of environmental laboratories and institutes to carry out the functions entrusted to such environmental laboratories and institutes under this Act;

(xii) Collection and dissemination of information in respect of matters relating to environmental pollution;

(xiii) Preparation of manuals, codes or guides relating to the prevention, control and abatement of environmental pollution;

(xiv) Such other matters as the Central Government deems necessary or expedient for the purpose of securing the effective implementation of the provisions of this Act.

PREVENTIONS, CONTROL & ABATEMENT OF ENVIRONMENTAL POLLUTION

Under section 7-: No person carrying on any industry, operation or process shall discharge or emit or permit to be discharged or emitted any environmental pollutants in excess of such standards as may be prescribed.

Under section 8: No person shall handle or cause to be handled any hazardous substance except in accordance with such procedure and after complying with such safeguards as may be prescribed.

Under Section 9:

(1) Where the discharge of any environmental pollutant in excess of the prescribed standards occurs or is apprehended to occur due to any accident or other unforeseen act or event, the person responsible for such discharge and the person in charge of the place at which such discharge occurs or is apprehended to occur shall be bound to prevent or mitigate the environmental pollution caused as a result of such discharge and shall also forthwith—

(a) Intimate the fact of such occurrence or apprehension of such occurrence; and

(b) Be bound, if called upon, to render all assistance, To such authorities or agencies as may be prescribed.

(2) On receipt of information with respect to the fact or apprehension on any occurrence of the nature referred to in sub-section (1), whether through intimation under that sub-section or otherwise, the authorities or agencies referred to in sub-section (2) shall, as early as practicable, cause such remedial measures to be taken as necessary to prevent or mitigate the environmental pollution.

(3) The expenses, if any, incurred by any authority or agency with respect to the remedial measures referred to in sub-section (2), together with interest (at such reasonable rate as the Government may, by order, fix) from the date when a demand for the expenses is made until it is paid,

may be recovered by such authority or agency from the person concerned as arrears of land revenue or of public demand.

Under section 10-: The central Government & its officers have the power to enter & inspect any place for the purpose of performing any function entrusted under the legislation.

Under Section 11-: The central Government & its officers have the power to take samples of air, water, soil or substances from factory or place, for analysis according to the laid down procedures in the act.

Under Section 12-: The central Government has the power.

(a) Establish one or more environmental laboratories;
(b) Recognize one or more laboratories or institutes as environmental laboratories to carry out the functions entrusted to an environmental laboratory under this Act.

Under section 13-: The central government may appoint or recognize Government Analysts for the purpose of analysis of samples of air, water, soil or other substance.

Under section 14-: Report signed by a Government analyst may be used as evidence of the facts stated therein in any proceeding under the legislation.

Penalties for Violating the Provisions in the Act

Under section 15-: Any person violating any provisions in the act shall be punishable with imprisonment for a term which may extend to five years with fine which may extend to one lakh rupees, or with both.

Under section 16-: The criminal liability is also fixed on the company's directors & principal officers in case of an offence committed by company.

Under section 17-: Where an offence under this Act has been committed by a Department of Government and it is proved that the offence has been committed with the consent or connivance of, or is attributable to any neglect on the part of, any officer, other than the Head of the Department, such officer shall also be deemed to be guilty of that offence and shall be liable to be proceeded against and punished accordingly.

Water (Prevention & Control of Pollution) Act, 1974

"Pollution" means such contamination of water or such alteration of the physical, chemical or biological properties of water or such discharge of any sewage or trade effluent or of any other liquid, gaseous or solid substance into water (whether directly or indirectly) as may, or is likely to, I create a nuisance or render such water harmful or injurious to public health or safety, or to domestic, commercial, industrial, agricultural or other legitimate uses, or to the life and health of animals or plants or of aquatic organizers.

"Sewage effluent" means effluent from any sewerage system or sewage disposal works and includes sullage from open drains;

"Trade effluent" includes any liquid, gaseous or solid substance which is discharged from any premises used for carrying on any "Industry, operation or process, or treatment and disposal system" other than domestic sewage.

Constitution of Central Pollution Control Board:

i. A full-time chairman, have special knowledge or practical experience in respect of [matters relating to environmental protection] or a person having knowledge and experience in administering institutions dealing with the matters aforesaid, to be nominated by the Central Government.
ii. Not more than five officials nominated by the Central Government.
iii. Not more than five persons nominated by the Central Government from amongst the members of state pollution control boards.
iv. The Central Board shall be a body corporate with the name aforesaid having perpetual succession and a common seal with power, subject to the provisions of this Act, to acquire, hold and dispose of property and to contract, and may, by the aforesaid name, sue or be sued.
v. Not more than five persons nominated by the Central Government to represent the companies or corporations owned by the central government.
vi. Not more than three person's non officials nominated by the Central Government to represent the interests of agriculture, *etc.*

Constitution of State Pollution Control Board

According to section 4 the State Pollution Control Board may be constituted having same constitution as the Central Pollution Control Board.

Constitution of Joint Pollution Control Board

According to section 14 of the act, under agreement between two or more contiguous states, Joint Pollution Control Board may be constituted for those states by central or state governments.

Function of the Central Pollution Control Board:

(a) Advising the Central Government on any matter concerning the prevention and control of water pollution.
(b) Co-coordinating the activities of the State Boards and resolve disputes among them.
(c) Providing technical assistance and guidance to the State Boards carry out and sponsor investigations and research relating to problems of water pollution and prevention, control or abatement of water pollution.
(d) Planning and organizing the training of persons engaged or to be engaged in programmes for the prevention, control or abatement of water pollution on such terms and conditions as the Central Board may specify.
(e) Organizing through mass media a comprehensive programme regarding the prevention and control of water pollution.
(f) Collecting, compiling and publishing technical and statistical data relating to water pollution and the measures devised for its effective prevention and control and prepare manuals, codes or guides relating to treatment and disposal of sewage and trade effluents and disseminate information connected therewith.

Function of the State Pollution Control Board:

(a) To plan a comprehensive programme for the prevention, control or abatement of pollution of streams and wells.
(b) To advise the State Government on any matter concerning the prevention, control or location of industrial units.
(c) To collect and disseminate information relating to water pollution and the prevention, control or location of industrial units.
(d) To encourage, conduct and participate in investigations and research relating to problems of water pollution and prevention, control or abatement of water pollution.
(e) To collaborate with the Central Board in organizing the training of persons engaged or to be engaged in programmes relating to prevention, control or abatement of water pollution and to organize certain related mass education programmes.
(f) To inspect sewage or trade effluents, works and plants for the treatment of sewage and trade effluents and to review plans, specifications or other data relating to plants set up for the treatment of water, works for the purification thereof and the system for the disposal of sewage or trade effluents or in connection with the grant of any consent as required by this Act.
(g) Lay downing, modifying or annul effluent standards for the sewage and trade effluents and for the quality of receiving waters (not being water in an inter-State stream) resulting from the discharge of effluents and to classify waters of the State.
(h) To evolve economical and reliable methods of treatment of sewage and trade effluents, having regard to the peculiar conditions of soils, climate and water resources of different regions and more especially the prevailing flow characteristics of water in streams and wells which render it impossible to attain even the minimum degree of dilution.
(i) To evolve methods of utilization of sewage and suitable trade effluents in agriculture.
(j) To evolve efficient methods of disposal of sewage and trade effluents on land, as are necessary on account of the predominant conditions of scant stream flows that do not provide for major part of the year the minimum degree of dilution.
(k) To lay down standards of treatment of sewage and trade effluents to be discharged into any particular stream taking into account the minimum fair weather dilution available in that stream and the tolerance limits of pollution permissible in the water of the stream, after the discharge of such effluents.

Power of the State Governments

Under the section 21: The state governments has the power to take for the purpose of analysis samples of water from any stream or well or samples of any sewage or trade effluent which is passing from any plant or vessel or from or over any place into any such stream or well.

Under the section 22: The state government has the power to obtain a report of the results of the analysis by a recognized laboratory.

Under the section 23: The State Pollution Control Board is empowered by the state government to enter any place for the purpose of performing any of the functions of the Board entrusted to it.

Under the section 24:

i. No person shall knowingly cause or permit any poisonous, noxious or polluting matter directly or indirectly into any stream, well or sewer or on land.
ii. No person shall knowingly cause or permit to enter into any stream any other matter which may impede the proper flow of the water of the stream in a manner leading or likely to lead to a substantial aggravation of water pollution

Under the section 25:

i. No person shall establish or take any steps to establish any industry, operation or process, or any treatment and disposal system or an extension which is likely to discharge sewage or trade effluent into a stream or well or sewer or on land.
ii. No person shall use begin to make any new discharge of sewage.
iii. No person shall bring into use any new or altered outlets for the discharge of sewage

Penalties for Violating the Provisions of the Act

In case of failure to provide information by a person discharging effluents into streams or well or regarding construction or establishment of an effluent disposal system, the penalty is imprisonment up to three months or fine up to Rs. 10000 per day or both. If the omission continues, the offender is penalized with additional fine up to Rs.5000 per day.

Wild life Protection Act

i. "Hunting", with its grammatical variations and cognate expressions, includes,-
   (a) Capturing, killing, poisoning, snaring and trapping of any wild animal and every attempt to do so.
   (b) Driving any wild animal for any of the purposes specified in sub-clause (a).
   (c) Injuring or destroying or taking any part of the body of any such animal or, in the case of wild birds or reptiles, damaging the eggs of such birds or reptiles or disturbing the eggs or nests of such birds of reptiles.
ii. "Animal" includes amphibians, birds, mammals and reptiles and their young, and also includes, in the cases of birds and reptiles, their eggs;
iii. "Habitat" includes land, water or vegetation which is the natural home of any wild animal;
iv. Animal article" means an article made from any captive animal or wild animal;

v. "Weapon" includes ammunition, bows and arrows, explosives, firearms, hooks, knives, nets, poison, snares and traps and any instrument or apparatus capable of anaesthetizing, decoying, destroying, injuring or killing an animal;
vi. "Wild life" includes any animal, bees, butterflies, crustacea, fish and moths; and aquatic or land vegetation which form part of any habitat.

Authorities Appointed

Appointment of Director and other officers:

i. The Central Government may, for the purposes of this Act, appoint,-
   (a) A Director of Wild Life Preservation.
   (b) Assistant Directors of Wild Life Preservation.
   (c) Such other officers and employees as may be necessary.
ii. The Assistant Directors of Wild Life Preservation and other officers and employees appointed under this section shall be subordinate to the Director.
iii. The Director shall be subject to such general or special directions providing by the Central Government.

Appointment of Life Warden and other Officers:

i. The State Government may, for the purposes of this Act, appoint,-
   (a) A Chief Wild Life Warden.
   (b) Wild Life Wardens.
ii. The Chief Wild Life Warden shall be subject to such general or special directions providing by State Government.

Wild life Advisory Board

Under section 6:

i. The Minister in charge of forests in the State or Union territory as the Chairman of the board, if there is no such Minister, the Chairman will be represented by, the Chief Secretary to the Government or the Chief Secretary to the Government of the Union territory.
ii. Two members of the State Legislature.
iii. The Forest officer in charge of the State Forest Department as an ex officio.
iv. An officer to be nominated by the Director.
v. Chief Wild Life Warden as an ex officio.
vi. Not more than five officers of the State Government

Duties of Wild Life Advisory Board

Under section 8:

i. Selection of areas to be declared as sanctuaries, National Parks and closed areas.
ii. Formulation of the policy for protection and conservation of the wild life and specified plants.

iii. The measures to be taken for harmonizing the needs of the tribals and other dwellers of the forest with the protection and conservation of wild life.
iv. Other matter connected with the protection of wild life which may be referred to it by the State Government.

Declaration of Sanctuary

Under section 18: The State Government may, by notification, declare its intention to constitute any area comprised within any reserve forest or the territorial waters as a sanctuary if it considers that such area is of adequate ecological, faunal, floral, geomorphological, natural or zoological significance, for the purpose of protecting, propagating or developing wild life or its environment

Restriction on Entry in Sanctuary

Under section 27: No person other than:
(a) A public servant on duty.
(b) A person who has been permitted by the Chief Wild Life Warden or the authorized officer to reside within the limits of the sanctuary.
(c) A person who has any right over immovable property within the limits of the sanctuary
(d) A person passing through the sanctuary along a public highway.
(e) The dependents of the person referred to in clause.

Declaration of National Parks

Under section 35: If the State Government feels that an area of adequate ecological, faunal, floral, geomorphological or zoological association or importance, needed to be constituted as National Park for the purpose of protecting, propagating or developing wild life therein or its environment.

Declaration of Closed Area

Under section 37:
i. The State Government may, by notification, declare any area closed to hunting for such period as may be specified in the notification.
ii. No hunting of any wild animal shall be permitted in a closed area during the period specified in the notification.

Prohibition of Hunting

No person shall hunt any wild animal specified in Schedule I, II, III and IV except as provided under section 11 and section 12.

Hunting of Wild Animals to be Permitted in Certain Cases

Under section 11:
i. The Chief Wild Life Warden is satisfied that any wild animal has become dangerous to human life or is so disabled or diseased as to be beyond

recovery, by order in writing and stating the reasons therefore, permit any person to hunt such animal or cause such animal to be hunted.

ii. The killing or wounding in good faith of any wild animal in defence of oneself or any other person shall not be an offence.

iii. Any wild animal killed or wounded in defence of any person shall be Government property.

Grant of Permit for Special Purposes

Under section 12: The Chief Wild Life Warden, by an order in writing stating the reasons therefore & on payment of such fees, may grant a permit to any person allowing him to hunt any wild life specified in such a permit, for the purpose of education, scientific research, scientific Management, derivation, collection or preparation of snake-venom for the manufacture of life- saving drugs.

Dealings in Trophy and Animal Articles without License Prohibited

Under section 44: No person shall, except under, and in accordance with, a license granted carry on the business as:

i. Manufacturer of or dealer in animal article.

ii. Cook or serve meat in any eating-house.

iii. Derive, collect or prepare, or deal in, snake venom.

Penalties

Under section 51:

i. Any person violating any of the provision of this act shall be punishable with imprisonment for a term which may extend to 3[three years] or with fine which may extend to 4[twenty-five thousand rupees] or with both.

ii. If any person is convicted of an offence against this act, the court may order that

Such person shall not eligible for a licence under the Arms Act, 1959 (54 of 1954), for a period of five years from the date of conviction.

FOREST (CONSERVATION) ACT, 1980

An Act to provide for the conservation of forests and for matters connected therewith or ancillary or incidental thereto. It extends to the whole of India except the State of Jammu and Kashmir. It shall be deemed to have come into force on the 25th day of October, 1980.

Restriction on the Dereservation of Forests or use of Forest Land for Non-forest Purpose

Under section 2: Notwithstanding anything contained in any other law for the time being in force in a State, no State Government or other authority shall make, except with the prior approval of the Central Government, any order directing-

(i) That any reserved forest (within the meaning of the expression "reserved forest" in any law for the time being in force in that State) or any portion thereof, shall cease to be reserved;
(ii) That any forest land or any portion thereof may be used for any non-forest purpose;
(iii) That any forest land or any portion thereof may be assigned by way of lease or otherwise to any private person or to any authority, corporation, agency or any other organization not owned, managed or controlled by Government;
(iv) That any forest land or any portion thereof may be cleared of trees which have grown naturally in that land or portion, for the purpose of using it for reafforestation.

Explanation -"non-forest purpose" means the breaking up or clearing of any forest land or portion thereof for:

(a) The cultivation of tea, coffee, spices, rubber, palms, oil-bearing plants, horticultural crops or medicinal plants;
(b) Any purpose other than reforestation. but does not include any work relating or ancillary to conservation, development and management of forests and wildlife, namely, the establishment of check-posts, fire lines, wireless communications and construction of fencing, bridges and culverts, dams, waterholes, trench marks, boundary marks, pipelines or other like purposes.

Constitution of Advisory Committee

Under section 3: The Central Government may constitute a Committee consisting of such number of persons as h may deem fit to advise that Government with regard to-

(i) The grant of approval, under Section 2; and
(ii) Any other matter connected with the conservation of forests which may be referred by the Central Government.

Penalty for Contravention of the Provisions of the Act

Under Section 3A: Whoever contravenes or abets the contravention of any of the provisions of Section 2, shall be punishable with simple imprisonment for a period which may extend to fifteen days

Offences by the Authorities and Government Departments

Under section 3B: Where any offence under this Act has been committed:

(a) By any department of Government, the head of the department; or
(b) By any authority, every person who, at the time the offence was committed, was directly in charge of, and was responsible to, the authority for the conduct of the business of the authority as well as the authority;

Shall be deemed to be guilty of the offence and shall be liable to be proceeded against and punished accordingly:

Power to Make Rules

Under Section 4: The Central Government may, by notification in the Official Gazette, makes rules for carrying out the provisions of this Act.

Repeal and Saving

(1) The Forest (Conservation) Ordinance, 1980 is hereby replaced.
(2) Notwithstanding such repeal, anything done or any action taken tinder the provisions of the said Ordinance shall be deemed to have been done or taken under the corresponding provisions of this Act.

AIR (PREVENTION AND CONTROL OF POLLUTION) ACT, 1981

To counter the problems associated with air pollution, ambient air quality standards were established, under the 1981 Act. The Act provides means for the control and abatement of air pollution. The Act seeks to combat air pollution by prohibiting the use of polluting fuels and substances, as well as by regulating appliances that give rise to air pollution. Under the Act establishing or operating of any industrial plant in the pollution control area requires consent from state boards. The boards are also expected to test the air in air pollution control areas, inspect pollution control equipment, and manufacturing processes. National Ambient Air Quality Standards (NAAQS) for major pollutants were notified by the CPCB in April 1994. These are deemed to be levels of air quality necessary with an adequate margin of safety, to protect public health, vegetation and property (CPCB 1995 cited in Gupta, 1999). The NAAQS prescribe specific standards for industrial, residential, rural and other sensitive areas. Industry-specific emission standards have also been developed for iron and steel plants, cement plants, fertilizer plants, oil refineries and the aluminium industry. The ambient quality standards prescribed in India are similar to those prevailing in many developed and developing countries.

To empower the central and state pollution boards to meet grave emergencies, the *Air (Prevention and Control of Pollution) Amendment Act*, 1987, was enacted. The boards were authorized to take immediate measures to tackle such emergencies and recover the expenses incurred from the offenders. The power to cancel consent for non-fulfilment of the conditions prescribed has also been emphasized in the Air Act Amendment.

The Air (Prevention and Control of Pollution) Rules Formulated in 1982

Defined the procedures for conducting meetings of the boards, the powers of the presiding officers, decision-making, the quorum; manner in which the records of the meeting were to be set, *etc.* They also prescribed the manner and the purpose of seeking assistance from specialists and the fee to be paid to them.

Complementing the above Acts is the *Atomic Energy Act* of 1982, which was introduced to deal with radioactive waste. In 1988, the *Motor Vehicles Act,*

was enacted to regulate vehicular traffic, besides ensuring proper packaging, labelling and transportation of the hazardous wastes. Various aspects of vehicular pollution have also been notified under the EPA of 1986. Mass emission standards were notified in 1990, which were made more stringent in 1996.

In 2000 these standards were revised yet again and for the first time separate obligations for vehicle owners, manufacturers and enforcing agencies were stipulated. In addition, fairly stringent Euro I and II emission norms were notified by the Supreme Court on April 29, 1999 for the city of Delhi. The notification made it mandatory for car manufacturers to conform to the Euro I and Euro II norms by May 1999 and April 2000, respectively, for new non-commercial vehicle sold in Delhi.

ANTIQUITY OF AIR POLLUTION

Air pollution, particularly in cities, is certainly not a new problem. Back in the Middle Ages the use of coal in cities such as London was beginning to escalate. The problems of poor urban air quality even as early as the end of the 16_{th} century are well documented. In the UK the Industrial Revolution during the 18_{th} and 19_{th} centuries was based on the use of coal. Industries were often located in towns and cities, and together with the burning of coal in homes for domestic heat, urban air pollution levels often reached very high levels. During foggy conditions, pollution levels escalated and urban smogs were formed. These often brought cities to a halt, disrupting traffic but more dangerously causing death rates to dramatically rise. The effects of this pollution on buildings and vegetation also became obvious. The 1875 Public Health Act contained a smoke abatement area to try and reduce smoke pollution in urban areas. During the first part of the 20_{th} century, tighter industrial controls lead to a reduction in smog pollution in urban areas. The 1926 Smoke Abatement Act was aimed at reducing smoke emissions from industrial sources, but despite the declining importance of coal as a domestic fuel, pollution from domestic sources remained significant.

The Great London Smog of 1952, which resulted in around 4,000 extra deaths in the city, led to the introduction of the Clean Air Acts of 1956 and 1968. These introduced smokeless zones in urban areas, with a tall chimney policy to help disperse industrial air pollutants away from built up areas into the atmosphere. Following the Clean Air Acts, air quality improvements continued throughout the 1970s. Further regulations were introduced through the 1974 Control of Air Pollution Act. This included regulations for the composition of motor fuel and limits for the sulphur content of industrial fuel oil. However, during the 1980s the number of motor vehicles in urban areas steadily increased and air quality problems associated with motor vehicles became more prevalent. In the early 1980s, the main interest was the effects of lead pollution on human health, but by the late 1980s and early 1990s, the effects of other motor vehicle pollutants became a major concern. The 1990s have seen the occurrence of wintertime and summertime smogs. These are not caused by smoke and sulphur dioxide

pollution but by chemical reactions occurring between motor vehicle pollutants and sunlight. These are known as 'photochemical smogs'. In 1995, the Government passed its Environment Act, requiring the publication of a National Air Quality Strategy to set standards for the regulation of the most common air pollutants. Published in 1997, the National Air Quality Strategy has set commitments for local authorities to achieve new air quality objectives throughout the UK by 2005. It is reviewed periodically.

HUMAN HEALTH

Healthy people do not normally notice any effects from air pollution, except when the pollution is very high. However, people sensitive to pollution, such as asthmatics, and those with heart conditions or lung diseases, may experience distress and other health effects, even at lower levels of pollution. The Government uses an air pollution banding system to describe the potential health impacts of poor air quality.

Particulates may be seen as the most critical of all pollutants, and some estimates have suggested that particulates are responsible for up to 10,000 premature deaths in the UK each year. The extent to which particulates are considered harmful depends largely on their composition. Sea salt, for example, is believed to have a positive effect on health. Man-made sources of particulates, however, are rarely harmless. In towns and cities, these are extensively from diesel vehicle exhausts. The effects of particulate emissions are considered detrimental due to their composition, containing mainly unburned fuel oil and hydrocarbons that are known to be carcinogenic among laboratory animals. Very fine particulates can penetrate deep into the lung and cause more damage, as opposed to larger particles that may be filtered out through the airways' natural mechanisms. Ozone differs from most pollutants in that it is created as a secondary pollutant by the action of sunlight on volatile organic compounds (VOCs) and oxides of nitrogen. Ozone is a toxic gas that can bring irreversible damage to the respiratory tract and lung tissue if delivered in high quantities. Asthmatics are known to adopt these symptoms more easily.

Nitrogen oxides consist mainly of nitrogen dioxide (NO_2) and nitric oxide (NO). Nitric oxide is more readily emitted to the atmosphere as a primary pollutant, from traffic and power stations, and is often oxidised to nitrogen dioxide following dispersal. The amount of nitrogen dioxide emitted directly to the atmosphere is relatively small. Nitric oxide is relatively non-toxic, but at high concentrations the health effects include changes to lung function. Nitrogen dioxide, however, is damaging to health, due to its toxicity. Health effects of exposure to nitrogen dioxide include shortness of breath and chest pains. Transport, tobacco smoke and gas appliances are the major sources of carbon monoxide. Its link with haemoglobin, the oxygen carrying component of the blood stream, forms carboxyhemoglobin (COHb) which can be life-threatening in high doses.

The effects of carbon monoxide pollution are more damaging to pregnant women and their foetus. Research into smoking and pregnancy shows that

concentrations within the blood stream of unborn infants is as high as 12 per cent, causing retardation of the unborn child's growth and mental development. A significant proportion of atmospheric lead comes from traffic emissions, due to the lead content in petrol. This has been significantly reduced in recent years but lead is still a serious air pollutant especially to those living near to areas of dense traffic. Damage to the central nervous system, kidneys and brain can result from high concentrations in the blood. Children, however, display vulnerability to the toxic effects of lead at much lower concentrations than for adults. It has been shown that there is a strong link between high lead exposures and impaired intelligence.

Even moderate concentrations of sulphur dioxide may result in a fall in lung function in asthmatics. Tightness in the chest and coughing may also result at higher levels.

Sulphur dioxide pollution is considered more harmful when particulate and other pollution concentrations are high. This is known as the "cocktail effect." Some VOCs are quite harmful. Benzene, for example, has been linked with an increase susceptibility to leukaemia, if exposure is maintained over a period of time.

INDOOR AIR POLLUTION

We spend a large part of our lives indoors at home. Keeping the air which we breathe at home clean is therefore of necessary importance, particularly for certain vulnerable members, including babies, children, pregnant women and the unborn babies, the elderly, and those suffering from respiratory or allergic diseases, such as asthma. In most homes the level of indoor air pollution is very low, because there are controls on the design and construction of buildings.

However, if ventilation of rooms is poor, or household appliances are faulty, pollution can build up to levels which may be detrimental to human health. There are many possible sources of air pollutants in the home and indoor air quality can vary widely. DIY work may lead to a temporary increase in indoor pollutants such as volatile organic compounds (VOCs), during painting or stripping in enclosed spaces, or laying loft insulation. Another significant source of indoor pollution is the burning of fuels in flueless appliances, such as paraffin stoves, portable gas heaters, gas stoves and ovens. If the appliance is faulty, incomplete combustion may result in the release of carbon monoxide, a highly poisonous gas.

Carbon monoxide also builds up when people smoke cigarettes indoors. Dirty homes or houses in disrepair may be a source of dustmite and mould spores. In some parts of the UK, and in other parts of the world, the radioactive gas radon can seep into the house from the underlying geology, and accumulate indoors if ventilation is poor.

Housing and public health legislation exists to help prevent air quality problems arising indoors in the first place. In the majority of homes there is no need for concern over existing levels of pollutants.

INDUSTRY AND POWER GENERATION

Industry and power generation are main sources of sulphur dioxide emissions, a common air pollutant and the precursor for sulphuric acid in acid rain. In the UK power stations and all other types of industry account for 90 per cent of all sulphur dioxide pollution. During the Industrial Revolution industries were often located in urban areas. Following the UK Clean Air Acts in the 1950s and 1960s, and with the decline in heavy industry, few large industries and power stations are located in towns and cities today. Many large industries are now located in the more rural areas of the UK. Consequently, sulphur dioxide pollution in urban areas has been significantly reduced.

The requirement of industries and power stations to disperse waste gases at elevated levels via a stack or chimney has also helped to reduce ground level concentrations of sulphur dioxide. However, this has significantly expanded the area of pollution dispersal, such that acid deposition is now the main pollution concern attributable to industry and power generation. Power stations contribute significantly to the total emissions of nitrogen oxides in the UK. In 1999, 21 per cent of nitrogen oxides came from this source and a further 13 per cent from other industries, iron and steel and refineries. The major source of nitrogen oxides pollution in the UK is now road transport (44 per cent). Like sulphur dioxide, nitrogen oxides are also converted into acidic compounds when combined with water in the atmosphere, and contribute to acid rain.

LEGISLATION

Ever since air pollution was recognised as a problem, legislators, regulators and governments have tried to control it. As early as 1273 the use of coal was prohibited in London as being "prejudicial to health". In 1306 the Royal Proclamation prohibited craftsmen from using sea-coal (a soft coal) in their furnaces. Since the beginning of the Industrial Revolution in Britain, numerous Acts have been passed in an attempt to reduce air pollution. These have included the Railway Clauses Consolidated Act of 1845 (requiring railway engines to consume their own smoke), the Improvement Clauses Act of 1847 (to reduce factory smoke), the Sanitary Act of 1866 (empowering sanitary authorities to take action in cases of smoke nuisances), the Public Health Act of 1875 (containing smoke abatement legislation that has been used to the present day), and the Smoke Abatement Act of 1926.

In the aftermath of the Great London Smog of 1952, the Government pass the two Clean Air Acts of 1956 and 1968, which aimed to control domestic sources of smoke pollution by introducing smokeless zones, and control industrial sources of pollution by the use of tall chimneys for waste gas dispersal. Since the 1970s when the UK joined the European Union, European legislation has been used to control the amount of pollution being emitted by industry, and now increasingly by transport. Over the last 30 years the European Commission has passed a number of EC directives to limit emissions of carbon monoxide,

lead, hydrocarbons and smoke emissions from road vehicles, and to set health limits for the common air pollutants, including sulphur dioxide, particulate matter, lead and nitrogen dioxide.

In response to European legislation, the UK Government passed the Environmental Protection Act (1990) and the Environment Act (1995), bringing many smaller emission sources under air pollution control by local authorities for the first time, and providing a new statutory framework for local air quality management. In 1997 the National Air Quality Strategy was published which sets air quality standards and targets for the pollutants of most concern. Many of these targets will need to be met by 2005.

LICHENS

Lichens are mutualistic associations of a fungus and an alga or cyanobacterium and occur as crusty patches or bushy growths on trees, rocks and bare ground. The names given to lichens strictly refer to the fungal partner; the algae have separate names. Lichens are very sensitive to sulphur dioxide pollution in the air. Since industrialisation, many lichen species have become extinct in large areas of lowland Britain, one example being the beard moss *Usnea articulata*. This is mainly due to sulphur dioxide pollution, but the loss of habitat, particularly ancient woodland, has also led to reductions in some species. Lichens are sensitive to sulphur dioxide because their efficient absorption systems result in rapid accumulation of sulphur when exposed to high levels of sulphur dioxide pollution. The algal partner seems to be most affected by the sulphur dioxide; chlorophyll is destroyed and photosynthesis is inhibited. Lichens also absorb sulphur dioxide dissolved in water.

Lichens are widely used as environmental indicators or bio-indicators. If air is very badly polluted with sulphur dioxide there may be no lichens present, just green algae may be found. If the air is clean, shrubby, hairy and leafy lichens become abundant. A few lichen species can tolerate quite high levels of pollution and are commonly found on pavements, walls and tree bark in urban areas. The most sensitive lichens are shrubby and leafy while the most tolerant lichens are all crusty in appearance. Since industrialisation many of the shrubby and leafy lichens such as *Ramalina, Usnea* and *Lobaria* species have had very limited ranges, often being confined to the parts of Britain with the purest air such as northern and western Scotland and Devon and Cornwall.

A lichen zone pattern may be observed in large towns and cities or around industrial complexes which corresponds to the mean levels of sulphur dioxide experienced. The most commonly used zonal index is the Hawksworth and Rose index, first published in 1970, consisting of a scale of 1 (poorest air quality) to 10 (purest air). Particular species of lichen present on tree bark can indicate the typical sulphur dioxide levels experienced in that area. For example if there are no lichens present, the air quality is very poor, whilst generally only crusty lichens such as *Lecanora conizaeoides* or *Lepraria incana* can tolerate poor air quality. In moderate to good air, leafy lichens such as *Parmelia caperata* or

Evernia prunastri can survive and in areas where the air is very clean, rare species such as 'the string of sausages' *Usnea articulata* or the golden wiry lichen *Teloschistes flavicans* may grow.

The Hawksworth and Rose index zonation index applies only to areas where sulphur dioxide levels are increasing. If sulphur dioxide conditions are falling, lichens rarely colonise in exactly the same sequence. Lichens are slow growing and may take a year or two to recolonise bark or other substrates following a reduction in air pollution levels, and tiny recolonising specimens can be difficult to spot and identify.

During the early and mid-twentieth century, air pollution levels were much greater than they are today in towns and cities of the UK. Sulphur dioxide levels were highest in the inner city areas becoming less polluted out towards the edges of the urban areas. At such times, the lichen zone scale would often highlight zone 1 as the inner city area, moving through the zones to the cleaner air at the edge of the city. From the 1970s onwards, sulphur dioxide levels have been falling markedly in the central and outer areas of cities, such that there may be no differentiation between levels in central and outer areas of many cities. The fall in sulphur dioxide levels between the 1970s and the present day has led to a number of lichens recolonising in areas from which they had already been eliminated.

4

Assessment of Environmental Impact

History of EIA in India:

- The Indian experience with Environmental Impact Assessment began over 20 years back. It started in 1976-77 when the Planning Commission asked the Department of Science and Technology to examine the river-valley projects from an environmental angle.
- Till 1994, environmental clearance from the Central Government was an administrative decision and lacked legislative support.
- On 27 January 1994, the then Union Ministry of Environment and Forests, under the Environmental (Protection) Act 1986, promulgated an EIA notification making Environmental Clearance (EC) mandatory for expansion or modernisation of any activity or for setting up new projects listed in Schedule 1 of the notification.
- The Ministry of Environment, Forests and Climate Change (MoEFCC) notified new EIA legislation in September 2006.
  - — The notification makes it mandatory for various projects such as mining, thermal power plants, river valley, infrastructure (road, highway, ports, harbours and airports) and industries including very small electroplating or foundry units to get environment clearance.
  - — However, unlike the EIA Notification of 1994, the new legislation has put the onus of clearing projects on the state government depending on the size/capacity of the project.

The EIA Process

EIA involves the steps mentioned below. However, the EIA process is cyclical with interaction between the various steps.

- *Screening:* The project plan is screened for scale of investment, location and type of development and if the project needs statutory clearance.
- *Scoping:* The project's potential impacts, zone of impacts, mitigation possibilities and need for monitoring.
- *Collection of baseline data:* Baseline data is the environmental status of study area.
- *Impact prediction:* Positive and negative, reversible and irreversible and temporary and permanent impacts need to be predicted which presupposes a good understanding of the project by the assessment agency.
- *Mitigation measures and EIA report:* The EIA report should include the actions and steps for preventing, minimizing or by passing the impacts or else the level of compensation for probable environmental damage or loss.
- *Public hearing:* On completion of the EIA report, public and environmental groups living close to project site may be informed and consulted.
- *Decision making:* Impact Assessment Authority along with the experts consult the project-in-charge along with consultant to take the final decision, keeping in mind EIA and EMP (Environment Management Plan).
- *Monitoring and implementation of environmental management plan:* The various phases of implementation of the project are monitored.
- *Assessment of Alternatives, Delineation of Mitigation Measures and Environmental Impact Assessment Report:* For every project, possible alternatives should be identified, and environmental attributes compared. Alternatives should cover both project location and process technologies.
    - — Once alternatives have been reviewed, a mitigation plan should be drawn up for the selected option and is supplemented with an Environmental Management Plan (EMP) to guide the proponent towards environmental improvements.

Definitions

There are a number of definitions of environmental assessment, EIA and SEA. Just a sample is given here. Environmental Impact Assessment (EIA) is a systematic and integrative process for considering possible impacts prior to a decision being taken on whether or not a proposal should be given approval to proceed.

Strategic Environmental Assessment (SEA) is a process of prior examination and appraisal of policies, plans, and programmes and other higher level or pre-project initiatives.

It is important to note that the terms defined above have differing interpretations and meanings in different countries, and that EIA and EA are often used interchangeably. In the UK, for example, the term EA has often been used to describe project-level assessment. However, for the purposes of this unit the definitions and distinctions introduced above are used.

The objective of EIA is not to force decision-makers to adopt the least environmentally damaging alternative, but rather to make explicit the environmental impact of the development, so that the environment is taken into account in decision-making. EIA has been regarded as both a science and an art, reflecting the technical aspects, such as impact identification and prediction, as well as the evaluation, management, and presentation of information. Before looking at EIA in more detail, it is worth looking at the nature of environmental change that needs to be considered to provide a context.

Objectives of Environmental Impact Assessment

In view of the colossal damage to the environment, there is a felt need for assessing the environmental impacts of developmental activities. EIA is a tool to anticipate the possible damage to the environment caused by developmental projects and schemes, and propose mitigation measures and strategies.

EIA exerts to declare a national policy to encourage productive and enjoyable harmony between man and environment. It promotes efforts to prevent or eliminate damage to the environment and the biosphere, and stimulate the health and welfare of man.

It seeks to increase the understanding of ecological system and nature resources important to the nation and to provide for appropriate institutional structure to carry out the objectives. It provides a broad, integrated perspective of a region about to undergo or undergoing developments. EIA ascertains the cumulative impacts from the multiple development in the region. It establishes priorities for environmental protection. It also identifies the positive and negative aspects of any project as well as assesses the policy options and analyzes the impact on the environment therein.

PUBLIC TRUST DOCTRINE, INDIAN JUDICIAL RESPONSE

PUBLIC TRUST DOCTRINE

The public trust doctrine is the principle that the sovereign holds in trust for public use some resources such as shoreline between the high and low tide lines, regardless of private property ownership.

Origins

The ancient laws of the Byzantine Emperor Justinian held that the sea, the shores of the sea, the air and running water was common to everyone. The

seashore, later defined as waters affected by the ebb and flow of the tides could not be appropriated for private use and was open to all. This principle became the law in England as well. Centuries later, *Magna Carta* further strengthened public rights. At the insistence of English nobles, fishing weirs which obstructed free navigation were to be removed from rivers.

These rights were further strengthened by later laws in England and subsequently became part of the common law of the United States. The Supreme Court first accepted the public trust doctrine in Martin v. Waddell's Lessee in 1842, confirming it several decades later in *Illinois Central Railroad v. Illinois*, 146 U.S., 387 (1892). In the latter case the Illinois Legislature had granted an enormous portion of the Chicago harbor to the Illinois Central Railroad. A subsequent legislature sought to revoke the grant, claiming that original grant should not have been permitted in the first place. The court held that common law public trust doctrine prevented the government from alienating the public right to the lands under navigable waters (except in the case of very small portions of land which would have no effect on free access or navigation).

The public trust applies to both waters influenced by the tides and waters that are navigable in fact. The public trust also applies to the natural resources (mineral or animal) contained in the soil and water over those public trust lands.

Application

This doctrine has been primarily significant in two areas: land access and use, and natural resource law.

Access to Ocean and Ponds

The doctrine is most often invoked in connection with access to the seashore. In the United States, the law differs among the fifty states but in general limits the rights of ocean front property owners to exclude the public below the mean high tide line.

Massachusetts and Maine (which share a common legal heritage) recognize private property ownership to the mean low tide line—but allow public access to the seashore between the low and high tide lines for "fishing, fowling and navigation," traditional rights going back to the Colonial Ordinance of 1647. Maine's Supreme Court in 2011 expanded the public trust doctrine by concluding fishing fowling and navigation are not an exclusive list; the court allowed the general public to cross private shoreline for scuba diving.

The public trust doctrine also finds expression in the Great Pond law, a traditional right codified in case law and statutes in Massachusetts, Maine, and New Hampshire. The state is said to own the land below the low water mark under great ponds (ponds over ten acres), and the public retains in effect an access easement over unimproved private property for uses such as fishing, cutting ice, and hunting.

In Oregon, a 1967 "Beach Bill" affirmed the state's public trust doctrine, and the right of the public to have access to the seashore virtually everywhere

between the low and high tide marks. In California the situation is more complicated: private landowners often try to block traditional public beach access, which can result in protracted litigation. Freshwater use rights have also been subject to litigation in California, under the public trust doctrine.

Natural resources

The doctrine has also been used to provide public access across and provide for continued public interest in those areas where land beneath tidally influenced waters has been filled. In some cases, the uses of that land have been limited (to transportation, for instance) and in others, there has been provision for public access across them.

The doctrine has been employed to assert public interest in oil resources discovered on tidally influenced lands (Mississippi, California) and has also been used to prevent the private ownership of fish stocks and crustacean beds.

In most states in the United States, lakes and navigable-in-fact streams are maintained for drinking and recreation purposes under a public-trust doctrine.

THE ROLE OF INDIAN JUDICIARY IN PROTECTION OF ENVIRONMENT IN INDIA

Environment is the wellspring of life on earth like water, air, soil, *etc.*, and determines the presence, development and improvement of humanity and all its activities. The concept of ecological protection and preservation is not new. It has been intrinsic to many ancient civilizations. Ancient India texts highlights that it is the dharma of each individual in the society to protect nature and the term 'nature' includes land, water, trees and animals which are of great importance to us. In the *'Atharva Veda'*, the ancient Hindu Scepters stated "What of thee I dig out let that quickly grow over".

At the same time, new innovations like, thermal power, atomic plant and so on without any sufficient natural assurance pose another danger to the situations, the aftereffect of which results in issues like global warming, climate change, acid rain, *etc.* Moreover, according to pattern of Indian legislature to make a number of legislations as opposed to addressing the reason for failure and disappointment, and passing new bills consistently is just like 'old wine in new bottle'.

Therefore, there arises a requirement for a comprehensive analysis of the protection of the environment. In recent years, there has been a sustained focus on the role played by the higher judiciary in devising and monitoring the implementation of measures for pollution control, conservation of forests and wildlife protection.

Many of these judicial interventions have been triggered by the persistent incoherence in policy-making as well as the lack of capacity-building amongst the executive agencies. Devices such as Public Interest Litigation (PIL) have been prominently relied upon to tackle environmental problems, and this approach has its supporters as well as critics.

Meaning of Environment

The word "environment" relates to surroundings. It includes virtually everything. It can be can defined as anything which may be treated as covering the physical surroundings that are common to all of us, including air, space, land, water, plants and wildlife. According to the Webster Dictionary, it is defined as the "Aggregate of all the external condition and influences affecting the life and development of an organism."

The Environment (Protection) Act, 1986

Section 2(a) environment "includes water, air and land and the inter-relationship which exists among and between water, air and land, and human beings, other living creatures, plants, micro-organism and property." Thus, after analyzing all the above definitions, the basic idea that can be concluded is that environment means the surroundings in which we live and is essential for our life.

Need for Environmental Laws

Today we are living in nuclear arena. No one can overlook the harm caused to the environment by the nuclear bombs, dropped by airplanes belonging to the United States on the Japanese urban communities of Hiroshima and Nagasaki amid the last phases of World War II in 1945. Day to day innovation and advancement of technology, apart from development additionally expands the risk to human life.

Accordingly, there arises an intense and an acute need of the law to keep pace with the need of the society along with individuals. So now the question of environmental protection is a matter of worldwide concern, it is not confined to any country or territory.

Judicial Remedies for Environment Pollution

The remedies available in India for environmental protection comprise of tortuous as well as statutory law remedies. The tortuous remedies available are trespass, nuisance, strict liability and negligence. The statutory remedies incorporates: Citizen's suit, *e.g.*,

- An activity brought under Section 19 of the Environmental (Protection) Act, 1986,
- An activity under area 133, Criminal Procedure Code, 1973.and
- And activity brought under the Section 268 for open irritation, under Indian Penal Code,1860

Apart from this, a writ petition can be filed under Article 32 in the Supreme Court of India or under Article 226 in the High Court.

Tortious Liability

The Indian judiciary has developed the following tortuous remedies:

Damage

In the recent case of *Shriram Gas Leak*, involving a leakage of Oleum gas which resulted in substantial environmental harm to the citizens of Delhi, the Apex court held that the quantum of damages awarded must be proportionate to the capacity and magnitude of the polluter to pay. However, the Apex Court has deviated from this test in the *Bhopal Gas Tragedy.*

Injunction

The purpose of injunction is to prevent continuous wrong. The grant of perpetual injunction is governed by Sec.37 to 42 of the Specific Relief Act, 1963.

Nuisance

Nuisance means the act which creates hindrance to the enjoyment of the person in form of smell, air, noise, *etc.*

According to Stephen, nuisance is anything done to hurt or annoyance of lands, tenements of another and not amounting to trespass.

Nuisance can be divided into two categories:

Private Nuisance – It is a substantial and unreasonable interference with the use and enjoyment of one's land. Public Nuisance – It is an unreasonable interference with a general right of the public.

Trespass

It means intentional or negligent direct interference with personal or proprietary rights without lawful excuses.

The two important requirements for trespass are:

(1) There must be an intentional or negligent interference with personal or proprietary rights.
(2) The interference with the personal or proprietary rights must be direct rather than consequential.

Negligence

It connotes failure to exercise the care that a reasonably prudent person would exercise in like circumstances.

Strict Liability

The rule enunciated in *Rylands v. Fletcher* by Blackburn J. is that the person who for his own purpose brings on his land and collects and keeps there anything likely to be a mischief, if it escapes, must keep it as its peril, and if he does not do so is prima facie even though, he will be answerable for all the damage which is the natural consequence of its escape. The doctrine of strict liability has considerable utility in environmental pollution cases especially cases dealing with the harm caused by the leakage of hazardous substances.

SOME REMARKABLE PRINCIPLES AND DOCTRINES PROPOUNDED BY THE INDIAN JUDICIARY

Doctrine of Absolute Liability

THE BHOPAL CASE: *Union Carbide Corporation* v. *Union Of India.*

In this case, the court held that, where an enterprise is occupied with an inherently dangerous or a hazardous activity and harm results to anybody by virtue of a mishap in the operation of such dangerous or naturally unsafe movement coming about, for instance, in getaway of poisonous gas, the enterprise is strictly and completely obligated to repay every one of the individuals who are influenced by the accident and such risk is not subject to any exemptions. Accordingly, Supreme Court created another trend of Absolute Liability without any exemption.

Polluter Pays Principles

"*If anyone intentionally spoils the water of another … let him not only pay damages, but purify the stream or cistern which contains the water…*" – Plato

Polluter Pays Principle has become a very popular concept lately. 'If you make a mess, it's your duty to clean it up '- this is the fundamental basis of this slogan. It should be mentioned that in environment law, the 'polluter pays principle' does not allude to "fault." Instead, it supports a remedial methodology which is concerned with repairing natural harm. It's a rule in international environmental law where the polluting party pays for the harm or damage done to the natural environment.

Vellore Citizen's Welfare Forum v. Union of India: The Supreme Court has declared that the polluter pays principle is an essential feature of the sustainable development.

Precautionary Principle

The Supreme Court of India, in Vellore Citizens Forum Case, developed the following three concepts for the precautionary principle:

Environmental measures must anticipate, prevent and attack the causes of environmental degradation.

Lack of scientific certainty should not be used as a reason for postponing measures.

Onus of proof is on the actor to show that his action is benign.

Public Trust Doctrine

The Public Trust Doctrine primarily rests on the principle that certain resources like air, water, sea and the forests have such a great importance to people as a whole that it would be wholly unjustified to make them a subject of private ownership.

M.C.Mehta v. Kamal Nath and Others: The public trust doctrine, as discussed by court in this judgment is a part of the law of the land.

Doctrine of Sustainable Development

The World commission on Environment and Development (WCED) in its report prominently known as the 'Brundtland Report' named after the Chairman of the Commission Ms. GH Brundtland highlights the concept of sustainable development. As per Brundtland Report, Sustainable development signifies " development that meets the needs of the present without compromising the ability of the future generations to meet their own needs". There is a need for the courts to strike a balance between development and environment.

Rural Litigation and Entitlement Kendra v. *State of UP:* The court for the first time dealt with the issue relating to the environment and development; and held that, it is always to be remembered that these are the permanent assets of mankind and or not intended to be exhausted in one generation.

Vellore Citizen's Welfare Forum: In this case, the Supreme Court observed that sustainable development has come to be accepted as a viable concept to eradicate poverty and improve the quality of human life while living within the carrying capacity of the supporting eco- system.

THE CONSTITUTIONAL ASPECTS ON ENVIRONMENTAL LAW

The Indian Constitution is amongst the few in the world that contains specific provisions on environment protection. The chapters directive principles of state policy and the fundamental duties are explicitly enunciated the nation commitment to protect and improve the environment. It was the first time when responsibility of protection of the environment imposed upon the states through Constitution (Forty Second Amendment) Act, 1976.

Article 48-A the provision reads as follows: "The State shall endeavor to protect and improve the environment and to safeguard the forest and wildlife of the country."The Amendment also inserted Part VI-A (Fundamental duty) in the Constitution, which reads as follows:

Article 51-A (g) "It shall be duty of every citizen of India to protect and improve the natural environment including forests, lakes,, and wildlife and to have compassion for living creature."

In *Sachidanand Pandey* v. *State of West Bengal*, the Supreme Court observed "whenever a problem of ecology is brought before the court, the court is bound to bear in mind Article 48-

A and Article 51-A(g).

ENVIRONMENTAL PROTECTION: THE JUDICIAL APPROACH

There are numbers of the following judgments which clearly highlight the active role of judiciary in environmental protection these are follows:

The Right to a Wholesome Environment

Charan Lal Sahu Case: The Supreme Court in this case said, the right to life guaranteed by Article 21 of the Constitution includes the right to a wholesome environment.

Damodhar Rao v. *S. 0. Municipal Corporation Hyderabad:* The Court resorted to the Constitutional mandates under Articles 48A and 51A(g) to support this reasoning and went to the extent of stating that environmental pollution would be a violation of the fundamental right to life and personal liberty as enshrined in Article 21 of the Constitution.

Public Nuisance: The Judicial Response

Ratlam Municipal Council v. *Vardhichand:* The judgment of the Supreme Court in instant case is a land mark in the history of judicial activism in upholding the social justice component of the rule of law by fixing liability on statutory authorities to discharge their legal obligation to the people in abating public nuisance and making the environmental pollution free even if there is a budgetary constraints., J. Krishna Iyer observed that," social justice is due to and therefore the people must be able to trigger off the jurisdiction vested for their benefit to any public functioning."Thus he recognized PIL as a Constitutional obligation of the courts.

Judicial Relief Encompasses Compensation to Victims

Delhi gas leak case: *M.C. Mehta v. Union of India*,

In instant case, the Supreme Court laid down two important principles of law:

(1) The power of the Supreme Court to grant remedial relief for a proved infringement of a fundamental right (in case if Article21) includes the power to award compensation.

(2) The judgment opened a new frontier in the Indian jurisprudence by introducing a new "no fault" liability standard (absolute liability) for industries engaged in hazardous activities which has brought about radical changes in the liability and compensation laws in India. The new standard makes hazardous industries absolutely liable from the harm resulting from its activities.

Fundamental Right to Water

The fundamental right to water has evolved in India, not through legislative action but through judicial interpretation. In *Narmada Bachao Andolan v. Union of India and Ors*., the Supreme Court of India upheld that "Water is the basic need for the survival of human beings and is part of the right to life and human rights as enshrined in Article 21 of the Constitution of India … and the right to healthy environment and to sustainable development are fundamental human rights implicit in the right to life.

Conclusion/Suggestions

Thus, after the analysis of above cases, we find that, the Supreme Court is, at the present time, stretching the different legal provisions for environmental protection. In this way, the judiciary tries to fill in the gaps where there is laciness

of the legislation. These new innovations and developments in India by the judicial activism open the numerous approaches to help the country. In India, the courts are extremely cognizant and cautious about the special nature of environmental rights, considering that the loss of natural resources can't be renewed. There are some recommendations which need to be considered.

Public Awareness

In India, media is the fourth pillar of the popular government. It plays an exceptionally essential and compelling part in the general improvement of the country. The effect of media can be seen in the different trials directed by it just by publishing them in their media. Accordingly, the issue of environmental pollution can be checked by making mindfulness in the general population, in which media's part is extremely critical. The compelling agency of correspondence not just influences the mind of the individuals but is also capable of developing thoughts and desirable attitudes of the people for protecting environment.

Regular Inspection

There is a requirement for a standard review apparatus, which can inspect and examine periodically every one of those exercises which are threatening the environment. This would be a successful step towards environment protection, since prevention is better than cure.

Environmental Education

There is no means for any law, unless it's an effective and successful implementation, and for effective implementation, public awareness is a crucial condition. Therefore, it is essential that there ought to be proper awareness. This contention is additionally maintained by the Apex Court in the instance of *M.C. Mehta v. Union of India*. In this case, Court directed the Union Government was obliged to issue directions to all the State governments and the union territories to enforce through authorities as a condition for license on all cinema halls, to obligatory display free of expense no less than two slides/messages on environment amid each show. Moreover, Law Commission of India in its 186th report made a proposal for the constitution of the environment court. Hence, there is an urgent need to strengthen the hands of judiciary by making separate environmental courts, with a professional judge to manage the environment cases/criminal acts, so that the judiciary can perform its part more viably

ENVIRONMENTAL AUDIT

Environmental auditing is essentially an environmental management tool for measuring the effects of certain activities on the environment against set criteria or standards. Depending on the types of standards and the focus of the audit, there are different types of environmental audit. Organisations of all kinds now recognise the importance of environmental matters and accept that their environmental performance will be scrutinised by a wide range of interested parties.

Environmental auditing is used to:

- Investigate
- Understand
- Identify

These are used to help improve existing human activities, with the aim of reducing the adverse effects of these activities on the environment. An environmental auditor will study an organisation's environmental effects in a systematic and documented manner and will produce an environmental audit report. There are many reasons for undertaking an environmental audit, which include issues such as environmental legislation and pressure from customers.

DEFINITIONS

The term 'audit' has its origins in the financial sector. Auditing, in general, is a methodical examination - involving analyses, tests, and confirmations - of procedures and practices whose goal is to verify whether they comply with legal requirements, internal policies and accepted practices.

The International Chamber of Commerce (ICC) produced a definition in 1989 which is along the same lines

A management tool comprising systematic, documented, periodic and objective evaluation of how well environmental organisation, management and equipment are performing with the aim of helping to safeguard the environment by facilitating management control of practices and assessing compliance with company policies, which would include regulatory requirements and standards applicable. There are other definitions available, although the above definition is still seen as the industry standard. The key concepts, which occur in all the definitions, are as follows.

- *Verification:* Audits evaluate compliance to regulations or other set criteria.
- *Systematic:* Audits are carried out in a planned and methodical manner.
- *Periodic:* Audits are conducted to an established schedule.
- *Objective:* Information gained from the audit is reported free of opinions.
- *Documented:* Notes are taken during the audit and the findings recorded.
- *Management tool:* Audits can be integrated into the management system (such as a quality management system or environmental management system).

Terminology

Environmental auditing should not be confused with environmental impact assessment (EIA). Both environmental auditing and EIA are environmental management tools, and both share some terminology, for example, 'impact', 'effect', and 'significant', but there are some important differences between the two.

Environmental impact assessment is an anticipatory tool, that is, it takes place before an action is carried out (*ex ante*). EIA therefore attempts to predict

the impact on the environment of a future action, and to provide this information to those who make the decision on whether the project should be authorised. EIA is also a legally mandated tool for many projects in most countries.

Environmental auditing is carried out when a development is already in place, and is used to check on existing practices, assessing the environmental effects of current activities (*ex post*). Environmental auditing therefore provides a 'snap-shot' of looking at what is happening at that point in time in an organisation.

The International Organization for Standardization (ISO) has produced a series of standards in the field of environmental auditing. These standards are basically intended to guide organisations and auditors on the general principles common to the execution of environmental audits. These are addressed elsewhere in this module.

5

Environment and Human Health

Environment related issues that affect our health have been one of the most important triggers that have led to creating an increasing awareness of the need for better environmental management. Changes in our environment induced by human activities in nearly every sphere of life have had an influence on the pattern of our health. The assumption that human progress is through economic growth is not necessarily true.

We expect urbanization and industrialization to bring in prosperity, but on the down side, it leads to diseases related to overcrowding and an inadequate quality of drinking water, resulting in an increase in waterborne diseases such as infective diarrhoea and air borne bacterial diseases such as tuberculosis.

High-density city traffic leads to an increase in respiratory diseases like asthma. Agricultural pesticides that enhanced food supplies during the green revolution have affected both the farm worker and all of us who consume the produce.

Modern medicine promised to solve many health problems, especially associated with infectious diseases through antibiotics, but bacteria found ways to develop resistant strains, frequently even changing their behaviour in the process, making it necessary to keep on creating newer antibiotics. Many drugs have been found to have serious side effects. At times the cure is as damaging as the disease process itself. Thus development has created several long-term health problems. While better health care has led to longer life spans, coupled with a lowered infant mortality, it has also led to an unprecedented growth in our population which has negative implications on environmental quality. A better health status of society will bring about a better way of life only if it is coupled with stabilising population.

ENVIRONMENTAL HEALTH

Environmental health, as defined by WHO, comprises those aspects of human health, including quality of life, that are determined by physical, chemical, biological, social, and psychosocial factors in the environment. It also refers to the theory and practice of assessing, correcting, controlling, and preventing those factors in the environment that adversely affect the health of present and future generations. Our environment affects health in a variety of ways.

Climate and weather affect human health. Public health depends on sufficient amounts of good quality food, safe drinking water, and adequate shelter. Natural disasters such as storms, hurricanes, and floods still kill many people every year.

Unprecedented rainfall trigger epidemics of malaria and water borne diseases. Global climate change has serious health implications. Many countries will have to adapt to uncertain climatic conditions due to global warming. As our climate is changing, we may no longer know what to expect.

There are increasing storms in some countries, drought in others, and a temperature rise throughout the world. The El Niño winds affect weather worldwide. The El Niño event of 1997/98 had serious impacts on health and well-being of millions of people in many countries. It created serious drought, floods, and triggered epidemics. New strategies must be evolved to reduce vulnerability to climate variability and changes.

Economic inequality and environmental changes are closely connected to each other. Poor countries are unable to meet required emission standards to slow down climate change.

The depletion of ozone in the stratosphere (middle atmosphere) also has an important impact on global climate and in turn human health, increasing the amount of harmful ultraviolet radiation that reaches the Earth's surface. This results in diseases such as skin cancer.

BHOPAL GAS TRAGEDY

The siting of industry and relatively poor regulatory controls leads to ill health in the urban centers. Accidents such as the Bhopal gas tragedy in 1984 where Union Carbide's plant accidentally released 30 tones of methyl isocyanate, used in the manufacture of pesticides, led to 3,330 deaths and 1.5 lakh injuries to people living in the area. Development strategies that do not incorporate ecological safeguards often lead to ill health. Industrial development without pollution control and traffic congestion affect the level of air pollution in many cities.

On the other hand, development strategies that can promote health invariably also protect the environment. Thus environmental health and human health are closely interlinked. An improvement in health is central to sound environmental management. However this is rarely given sufficient importance in planning development strategies.

EXAMPLES OF THE LINKAGES

- Millions of children die every year due to diarrhoea from contaminated water or food. An estimated 2000 million people are affected by these diseases and more than 3 million children die each year from waterborne diseases across the world. In India, it is estimated that every fifth child under the age of 5 dies due to diarrhoea. This is a result of inadequate environmental management and is mainly due to inadequate purification of drinking water. Wastewater and/or sewage entering water sources without being treated leads to continuous gastrointestinal diseases in the community and even sporadic large epidemics. Large numbers of people in tropical countries die of malaria every year and millions are infected. An inadequate environmental management of stagnant water, which forms breeding sites of Anopheles mosquitoes is the most important factor in the spread of malaria. The resurgence of malaria in India is leading to cerebral malaria that affects the brain and has a high mortality.
- Millions of people, mainly children, have poor health due to parasitic infections, such as amoebiasis and worms. This occurs from eating infected food, or using poor quality water for cooking food. It is estimated that 36% of children in low-income countries and 12% in middle income countries are malnourished. In India, about half the children under the age of four are malnourished and 30% of newborns are significantly underweight.
- Hundreds of millions of people suffer serious respiratory diseases, including lung cancer and tuberculosis, from crowded homes and public places. Motor vehicle exhaust fumes, industrial fumes, tobacco smoke and cooking food on improper 'chulas', contribute to respiratory diseases.
- Millions of people are exposed to hazardous chemicals in their workplace or homes that lead to ill health due to industrial products where controls are not adhered to.
- Tens of thousands of people in the world die due to traffic accidents due to inadequate management of traffic conditions. Poor management at the accident site, and inability to reach a hospital within an hour causes a large number of deaths, especially from head injuries.
- Basic environmental needs such as clean water, clean air and adequate nutrition which are all related to environmental goods and services do not reach over 1000 million people living in abject poverty.
- Several million people live in inadequate shelters or have no roof over their heads especially in urban settings. This is related to high inequalities in the distribution of wealth and living space.
- Population growth and the way resources are being exploited and wasted, threatens environmental integrity and directly affects health of nearly every individual.

- Health is an outcome of the interactions between people and their environment. Better health can only come from a more sustainable management of the environment.

HEALTH IMPACT ASSESSMENT (HIA) BY WHO

Health impact assessment is a combination of procedures, methods and tools by which a policy, programme or project may be judged as to its potential effects on the health of a population, and the distribution of those effects within the population.

CLIMATE AND HEALTH

Human civilizations have adapted mankind to live in a wide variety of climates. From the hot tropics to the cold arctic, in deserts, marshlands and in the high mountains. Both climate and weather have a powerful impact on human life and health issues. Natural disasters created by extremes of weather (heavy rains, floods, hurricanes) which occur over a short period of time, can severely affect health of a community. Poor people are more vulnerable to the health impacts of climate variability than the rich.

Of approximately 80,000 deaths which occur world-wide each year as a result of natural disasters about 95% are in poor countries. In weather-triggered disasters hundreds of people and animals die, homes are destroyed, crops and other resources are lost.

Public health infrastructure, such as sewage disposal systems, waste management, hospitals and roads are damaged. The cyclone in Orissa in 1999 caused 10,000 deaths.

The total number of people affected was estimated at 10 to 15 million! Human physiology can adapt to changes in weather, within certain limits. However, marked short-term fluctuations in weather lead to serious health issues. Heat waves cause heat-related illness and death (*e.g.,* heat stroke). The elderly and persons with existing heart or respiratory diseases are more vulnerable. Heat waves in India in 1998 were associated with many deaths.

Climate plays an important role in vector-borne diseases transmitted by insects such as mosquitoes. These disease transmitters are sensitive to direct effects of climate such as temperature, rainfall patterns and wind.

Climate affects their distribution and abundance through its effects on host plants and animals. Malaria transmission is particularly sensitive to weather and climate.

Unusual weather conditions, for example a heavy downpour, can greatly increase the mosquito population and trigger an epidemic. In the desert and at highland fringes of malarious areas, malaria transmission is unstable and the human population lacks inherent protective immunity.

Thus, when weather conditions (rainfall and temperature) favour transmission, serious epidemics occur in such areas. Fluctuations in malaria over the years have been linked to changes in rainfall associated with the El Niño cycle.

INFECTIOUS DISEASES

Many infectious diseases have re-emerged with a vengeance. Loss of effective control over diseases such as malaria and tuberculosis, have led to a return of these diseases decades after being kept under stringent control. Other diseases were not known to science earlier and seem to have suddenly hit our health and our lives during the last few decades. AIDS, due to the Human Immunodeficiency Virus (HIV) caused through sexual transmission and Severe Acute Respiratory Syndrome (SARS) are two such examples.

While these cannot be directly related to environmental change, they affect the environment in which we live by forcing a change in lifestyles and behaviour patterns. For example the SARS outbreak prevented people from several countries from traveling to other countries for months, severely affecting national economies, airline companies and the tourism industry. Why have infectious diseases that were related to our environment that were under control suddenly made a comeback? Diseases such as tuberculosis have been effectively treated with anti-tubercular drugs for decades.

These antibiotics are used to kill off the bacteria that causes the disease. However nature's evolutionary processes are capable of permitting bacteria to mutate by creating new genetically modified strains. Those that change in a way so that they are not affected by the routinely used antibiotics begin to spread rapidly. This leads to a reemergence of the disease. In the case of tuberculosis this has led to multi-drug resistant tuberculosis.

This is frequently related to HIV which reduces an individual's immunity to bacteria such as mycobacterium tuberculosis that causes tuberculosis. The newer broad-spectrum antibiotics, antiseptics, disinfectants, and vaccines once thought of as the complete answer to infectious diseases have thus failed to eradicate infectious diseases.

Experts in fact now feel that these diseases will be the greatest killers in future and not diseases such as malignancy or heart disease. While antibiotic resistance is a well-known phenomenon there are other reasons for the reemergence of diseases.

Overcrowding due to the formation of slums in the urban setting leads to several health hazards, including easier spread of respiratory diseases. Inadequate drinking water quality and poor disposal of human waste due to absence of a closed sewage system and poor garbage management are all urban health issues.

This has led to a comeback of diseases such as cholera and an increased incidence of diarrhea and dysentery as well as infectious hepatitis (jaundice). With increasing global warming disease patterns will continue to change. Tropical diseases spread by vectors such as the mosquito will undoubtedly spread malaria further away from the equator.

Global warming will also change the distribution of dengue, yellow fever, encephalitis, *etc.* Warmer wetter climates could cause serious epidemics of diseases such as cholera. El Nino which causes periodic warming is likely to affect rodent populations. This could bring back diseases such as the plague.

Globalisation and infectious disease Globalization is a world-wide process which includes the internationalization of communication, trade and economic organization. It involves parallel changes such as rapid social, economic and political adjustments. Whilst globalization has the potential to enhance the lives and living standards of certain population groups, for poor and marginalized populations in both the non-formal as well as formal economic sectors of developing countries, globalization enhances economic inequalities.

QUALITY MANAGEMENT AND ENVIRONMENTAL MANAGEMENT

Total quality management (TQM) (also called company-wide quality management) aims to provide assurance of adherence to policy and specifications through a structured management system, and to enable demonstration of it to third parties through documentation and record-keeping.

TQM was first formulated in the USA, and largely developed in Japan in the early post-war period to try to improve industrial competitiveness. Environmental management systems (EMSs) show adherence to a suitable environmental policy, the meeting of appropriate environmental objectives (equivalent to specifications in quality management) and the ability to demonstrate to a wide range of interested parties ('customers' in TQM) that the system requirements and objectives are met. EMSs, usually require that a company or body publishes and regularly updates an Environmental Policy Statement.

An EMS provides an organizational structure, procedures and resources for implementing environmental policy. It also provides a language of performance and quality that can be understood by management. So far, adoption of EMS has mainly been voluntary with rapid growth of interest and continuing modification and improvement. Hunt and Johnson suggested this indicates business has shifted from 'defensive environmental management' to accepting the need for probity. There are critics of EMSs, who argue it is possible to rig them by setting easy-to-achieve targets; that it is more important (and difficult) to nurture satisfactory environmental ethics; and that EMS is still being developed and tested.

A government or other regulatory body can provide companies with a more stable regulatory environment and encourage development of better pollution control plans or adoption of an EMS through a covenant. This is a written, voluntary agreement signed by the company or other body and the government or agency seeking regulation. The Netherlands has made extensive use of covenants as part of an integrated approach to national environmental management policy.

A Dutch company undertaking a covenant would be expected to produce a development plan every four years, to be reviewed by local authorizing bodies. The plan coverage includes pollution control and energy conservation and it is seen as a way of getting national policies implemented at local level. Measures were initiated by the National Environmental Policy Plans (adopted by the Dutch

Parliament in 1989), and by 1997 over 1,200 companies had signed covenants. The covenanting approach can be quite effective, particularly in cutting pollution. However, some NGOs are not keen on the approach, viewing it as closed or cosy and not sufficiently open to third parties to check. There are also some worries that it may lead to a softening of enforcement controls. Nevertheless, it is an approach which encourages company self-regulation.

Life-cycle Analysis

Many development activities are processes which have different stages—for example, manufacturing a car or running a power station involve raw materials and energy provision, plant construction, manufacturing, distribution, use and disposal or decommissioning. Equipment is usually subject to wear and tear, and so varies in performance and presents different risks as it ages and as management acquire experience (or become complacent). Industrial and power generation sites, for example, often accumulate contamination, and so the environmental threat is not constant. It is therefore undesirable to assess impacts or develop environmental management policies by simply taking a snapshot view. Life-cycle analysis (or assessment) has been developed to try to consider the whole of an activity, which may extend beyond the time horizon of a single owner. It is cradle-to-grave study of an activity or company.

The Current Situation

One may summarize the present situation as:

- The majority of businesses are aware that environmental issues are important;
- Some businesses are doing something—it may be from genuine concern, but often it is for public relations or profit motives;
- Too often businesses adopt a 'react and repair' approach, rather than following precautionary principles;
- Only a few businesses are acting at a strategic level;
- Business is in need of strategies like industrial ecology, but will need to be encouraged or forced to adopt them.

IMPLICATIONS OF ENVIRONMENTAL POLICY

The sensitive nature of a national environmental information system makes it entirely dependent on the policy adopted by the central government in relation to the human and the natural environment, since it is intended to support government programmes, and it is, moreover, maintained by government.

Six points have been identified as the main components of environmental policy which could determine the basic characteristics of an environmental information system.

These components are:

- Strategy on natural resources
- Industrial development objectives

- Pollution criteria and parametres
- International exchange platform
- Attitudes towards public participation
- Subject areas of R & D encouraged

Conservationist Policy

When the central government adopts a conservationist policy in the management of environment the results may be as follows:

Strategy on natural resources. Emphasis will be on natural resources, in a search for their protection for ecological reasons and their preservation for future generations. As a whole, in this situation there will be a smaller volume and less variety of data to be managed by the information system than under either of the other two policies. However, the area of natural resources will probably be the strongest feature in the system.

Industrial development objectives. The government will probably not encourage the implementation of industries because it values a clean environment more than the economic growth of the country. Environmentally sound technology will be welcome, even though government is not deeply involved in supporting its development. Thus, the information system will have a weak monitoring activity and lack of data on pollution and the socioeconomic environment but a good deal of information on alternative technologies.

Pollution criteria and parametres. Regulations to control pollution are very restrictive as part of the scheme to discourage industrial development. There will be emphasis on the promotion and collection of studies like environmental impact statements. International exchange platform. Conservationists are usually prone to considering the environment as a common inheritance of all living beings. If held in governmental circles, this attitude is likely to lead authorities to adopt, in diplomatic and international discussions, an open position about environmental subjects. It may also lead to a disposition towards the free international exchange of information and willing participation in any international information networks. Attitude towards public participation. Government will welcome public participation in environmental affairs. However, the fact that government is already meeting environmental needs may mean that less public pressure is exerted on the subject and, accordingly, that less information support is demanded. If it really occurs, the information system will not be a priority for government unless channelled for public education on ecological matters.

Subject areas of R&D encouraged. Government will tend to sponsor educational and research programmes in subject areas related to natural sciences and landscape planning, and so the supporting information systems will be sponsored as well. There will be a tendency for users of the information system to be scientists and researchers, followed by environmental managers.

Ecodevelopmental Policy: When government has taken an eco-developmental line, the whole planning system is directed to environmentally sound socioeconomic development, presenting the following specific tendencies:

Strategy on natural resources. Nature is seen as a benefit to be shared by the whole world and a resource to be thoughtfully used and individually managed by each country. Information will be needed about: (a) the basic components of the environment (air, water, soil), both from the theoretical approach to nature and from a practical view of local environment; (b) products of soil and water, the so-called renewable natural resources, from both naturalistic and economic points of view and under both global and local approaches; (c) mineral resources, their nature, reserves, careful means of exploitation and research data on potential renewable substitutes; and (d) recycling of resources.

Industrial development objectives. Industrial expansion is an important issue, and government emphasizes the development of technology appropriate to the physical and the socioeconomic environment of the country. Transfer of technology is considered in accordance with priorities of the recipient country, and exchange of information—especially on AT—among developing countries is highly considered.

The information system will develop a collection of data and documents on technological and socioeconomic facets of industrial development. Hard data will be demanded as much as qualitative information.

All possible information on resources—conserving, raw material saving, low-energy, low-waste and nonencroaching technologies should be collected and made available. Information should also be supplied on methods of assessing environmental impact and undesirable deterioration by natural disasters and human misuse. The social subset of the information system dealing with the human environment is going to be highly considered and demanded by the government.

Pollution criteria and parametres. Pollution control regulation is quite comprehensive and more flexible, as the parametres vary regionally according to the carrying capacity of the local environment.

This flexibility is part of the strategy to attract industries and keep them under the control of the local environmental agency. Monitoring systems, in this case, must be quite complex, and the resulting data are going to be a subset of the information system. The environmental impact statements are equally valuable. Information on the social aspects of pollution associated with poverty and bad sanitary conditions might receive high consideration.

International exchange platform. Ecodevelopment pays particular attention to developing countries sharing the same problems and similar environmental conditions. However, most of the studies and research are carried out in developed countries. Backward nations adopting an ecodevelopmental policy are usually open to an international exchange of information, even though they are also very zealous in the pursuit of their national sovereignty.

Developing countries will always expect to receive information from the developed world, but they tend to be reluctant to supply information about their own resources and policies if the requesting country is not an ally or does not belong to the same politico-economic group. In this context, the developing country may participate officially in international information networks, but

the ambivalent nature of its participation is likely to create some practical difficulties with the other members and ethical problems for information workers.

Attitudes towards public participation. Government will encourage public participation, which is expected to occur in all representative groups of society, which will be manifesting different positions.

It will result in high pressure on the government and, consequently, on the information system. Data and document collection must range from conservation of natural resources and the social aspects of the human environment to high technology for industrial development, not disregarding information to the general public about means of solving routine environmental problems. All forms of community information will come under the umbrella of an ecodevelopment policy of government.

Subject areas of R&D encouraged. Government will give incentives to educational and research programmes in a variety of environment-related subjects, such as natural sciences, agriculture, environmental and sanitary engineering, AT, environmental education, environmental medicine and urban and landscape planning. Therefore, environmental information systems must be prepared to satisfy demands related to these programmes. Users will also represent the following variety of interests: environmental managers, governmental planners, scientists and technologists, social scientists, researchers, lecturers and, by extension, the population as a whole.

Technocratic Policy

A technocratic government tends to mean development at any cost, with environmental disruption accepted as a by-product of progress. In these circumstances the tendencies are as follows:

Strategy on natural resources: Nature is regarded solely as an economic resource to be used in the most profitable way. The information required about natural resources will always show the economic bias of government and will stress the demand of quantitative aspects and the available technology to exploit existing resources. Data on natural resources, mainly mineral reserves, are a fundamental requirement of government and usually considered a sensitive subject.

Industrial development objectives: A technocratic government tends to understand development as being synonymous with economic growth and to consider industrial expansion as the way to reach it. It will have little concern for protecting the environment and preventing pollution. Information will be demanded on cheap, profitable technologies, whether or not they are harmful to the environment or to people.

Pollution criteria and parametres: Pollution control regulation is quite limited and parametres very lax, so that industries are not deterred from coming to the country in question. Some monitoring is performed in order to alleviate the consquences of heavy pollution. Social information related to pollution of poverty may eventually receive some consideration, with marginal interest, to back up development programmes.

International exchange platform: Backward countries with great ambitions to develop try to get the maximum in resources and knowledge from outside in order to reach their goals more quickly.

At the same time they attach some secrecy to information about their own natural reserves, which they plan to exploit on their own behalf in the future. These countries have a very conflicting international relationship, as they need and want help, but they are not willing to renounce some rights to their national sovereignty in exchange.

It rebounds on the information scene by creating an ambiguous position: central government controls main decisions about international exchange and is eager to receive information but is very secretive in giving it to foreign countries. This position makes it more difficult for them to participate in international networks or to collaborate with information systems of supranational organizations.

Attitude towards public participation. Government will not give incentives to public movements in favour of protecting the environment, but these will certainly occur as a result of the official neglect of the natural and the social environment.

Nor will programmes of environmental education be given much incentive. However, information systems will be asked to follow the development of the ecological movement, at both national and international levels, in order to provide government with necessary information to support its policies and promote its good environmental public image. The information system will probably be a high priority for a technocratic government, as it associates scientific and technological information with economic development.

Subject areas of R&D encouraged. Government will give incentives to development of applied knowledge. R&D information will be accordingly promoted, mainly in areas of industrial technology, agriculture and all different branches of engineering, where the abatement of pollution will also be included. Users will be mainly government planners and technologists.

Since the political process is very dynamic, the overall policy adopted by government in the management of a country's environment will determine the specific policy of environmental information. Reciprocally, that policy is also likely to be influenced by the information available to policymakers. In the potential of information professionals to persuade environmental policymakers lies a great deal of their power to cooperate for the betterment of life quality on Earth and especially in the Third World. This improvement cannot be achieved without environmentally sound development and the assurance of justice for all.

6

Environmental Challenges Posed by Climate Change

India should be an active and decisive partner, along with other developing countries, in climate change negotiations. We need to ask: What concentration levels, along with the associated risks, are acceptable to developing countries? How could it be ensured that the risks to the developing countries, and not just the costs to the developed countries, are minimised? The assumptions about greenhouse gas (GHG) concentration levels for stabilisation of atmospheric concentrations range from 450, 550 and even 1000 ppmv. It should be noted that according to the IPCC third assessment report, increase of CO_2 concentrations in this range can lead to an equilibrium warming of between 2.0°C to 4.8°C.

The IPCC report probably specified a specific CO2 concentration increase with which the warming of 2 – 4.8 degrees was associated? Each of these concentration levels permits different reduction strategies. Freedom to choose options is more limited in the case of 450 ppmv as carbon budgets are very low and therefore greater mitigation action is required in the nearer term.

Integrated assessment models are currently being developed to consider these issues. Unfortunately, assumptions, premises and paradigms dictate the results of these models. In the view of the authors, often the developed countries' perspectives are hardwired into the models in such a manner that even if many scenarios are generated, the basic theme and results do not change.

For example, these models focus on minimising costs to the developed countries and not the risks to the developing countries. Yet, the decision about

what is an acceptable level of climate change should centre around the risks to the developing countries. In fact, the developing countries should have a greater say as they are more vulnerable to the impact of climate change, they have a very small share in the cumulated emissions and thus have less responsibility for the problem of global warming; they are also poor and their emission trajectories are likely to rise due to development.

In no other environmental issue are large polluters given opportunities to decide what cost and efforts are acceptable to them without full consideration of the vulnerability of the others. The level of effort needed to address an environmental issue is decided on the basis of what is good for society. For climate change, this will depend upon what risks of climate change impacts are associated with different levels of emissions. Some of the types of risks and cost implications of climate change for India. India is a large country with wide ranging soil climate and other natural conditions. The results for India are thus likely to represent developing countries as a whole. Such risks to poor countries should be the primary focus of the climate change analysis, rather than costs to the developed countries. To this extent, a paradigm shift is necessary from the cost-minimisation to risk- minimisation in the future analyses of IPCC. Of course, the nature and extent of climate change and its impacts are uncertain. That, however, should not be grounds for inaction. We should find a way to deal with differing perspectives on uncertainty and risk. We offer a suggestion for this later.

What are the implications of the differentiated responsibilities accepted under FCCC? If we look at the factors driving emissions, we get an idea. Parikh J modification of the Kaya identity states: Thus, carbon intensity of the energy system and energy intensity of GDP have to be also reduced to compensate for an increase in carbon due to an increase in GDP and population so as to reduce total emissions.

The Parikh identity also suggests that in the long-term population reduction, GDP stabilisation and other such measures that may be considered drastic by today's standards, will be in the arena of desirable options, if the climate change problem turns out to be more serious than it appears today and if through technology development we are unable to decouple carbon from energy use. Parikh J gives a detailed plan about step by step reduction for both developing and developed countries.

To stabilise or reduce carbon emissions in a smooth transition, one has to proceed in steps. Thus, first reduce the rate at which carbon emissions are growing, then make this rate zero, *i.e.*, stabilise carbon emissions and then make the rate negative, *i.e.*, reduce emissions.

For example, fossil fuel growth rates in OECD countries used to be in the range of 3% to 7% in the 70s, which came down in the range of 0% or ± 1%. On the other hand, emission growth rates in developing countries increased until the 1990s, but are showing signs of deceleration in many major countries such as India and China due both to reduced population growth as well as to reduction

in energy intensity of GDP (E/Y and to some extent in carbon intensities (C/E) due to substitution of coal with oil and gas). Yet these growth rates are at high level and further reduction in these growth rates is required after which they will also have to be stabilised of course, but that will take many decades.

This is a possible scenario. Carbon emissions in countries kept growing up to 1990 but at a decreasing rate. During the 1990's, emissions did not grow. From 2001 onwards, their emissions have to fall at an increasing rate. Carbon emissions will keep growing till 2050. The growth rate increases till 2000, remains stable from 2001 to 2025, and starts declining thereafter – becoming negative by 2050.

Discounting the Future

There is an implicit discount rate. It is often argued that the future generations would be richer and hence we can pass on the burden of emission mitigation on them. Some even suggested that they have to be similar to those used in any other investment strategy. It is often argued by some countries that we should use a high discount rate in designing climate change mitigation strategies. In our view, this is not quite correct.

Climate change, if it is permitted to happen, will impose a heavy burden on future generations in ALL countries not just on the citizens of countries. Even after 50 years, Indian nationals are likely to be poorer than those of the OECD are today.

Thus, by not taking actions now the burden is transferred not just to rich citizens of the OECD of the next generation but also to poorer Indians of tomorrow who would be poorer than today's citizens of OECD. A low discount rate is more appropriate when assessing optimal mitigation strategies.

DELAY IS FREE RIDING

Despite the commitments made at Rio, the countries have taken little action to meet their commitments. At the Conference of Parties (COP) in Kyoto in 1997, too, countries again delayed their commitments. On the whole the countries are expected to reduce their emission by 5.2% in the next fifteen years over their 1990 levels. Of this, the USA is expected to reduce by 7%, the EU by 8% and Japan by 6%. Even what little they agreed has still to be ratified in their home countries. Countries need to take urgent actions through a consensus-building exercise to engage local decision- makers. Through delays, rich OECD countries are occupying global environmental space.

During 1990 to 2020 (during which period they were supposed to act, haven't acted and are not likely to act) OECD countries would have emitted more than India would emit in the next 30 years, assuming a 5% increase in India's GHG emission every year. Point a shows the present emission level, and point c the target emission level in the year 2010.

The objective is to go from point a to point c. Path abc is the path that is likely to be followed if OECD countries were to fulfil their Kyoto obligations.

Path adc, is the likely path of OECD emissions had they taken their FCCC commitment made at Rio seriously. While both the paths reach the same level, path abc puts much more CO2 in the atmosphere. The shaded area shows the additional CO_2 OECD countries have emitted and it would lead to higher temperature rise.

One can recognise that this delay is costing India and other developing countries opportunities to develop in the future. Through delay OECD countries are further occupying global environmental space, and since Kyoto they have asked for even more of a delay. Delaying Kyoto is really reneging on Rio. To discourage free riding during the negotiation period and beyond, we suggest that countries are accountable for their own emissions for a specific period, say after 1990 or 2000.

That is, whatever decisions are arrived at, will be applicable retroactively from, say, 2000. That is, the clock starts ticking and all emissions are cumulated for each country even during negotiations. This way, negotiations will conclude faster and policy actions to reduce emissions will begin soon. Regardless of the outcome of the negotiations, these emissions will be shown against each country and that much less will be available to them in future. Thus, the countries taking actions in advance get their rewards and procrastinating countries will have to do more later.

Mitigation Costs and Benefits

Reluctance to take action now implies a faith in technical progress to effectively deal with **climate change** later. This is a risky strategy which the poor and vulnerable will find hard to accept. Technical progress sometimes brings with it unanticipated consequences. When CFCs where introduced, they were hailed as a great technical innovation – but, as it known now, they had the side-effect of leading to ozone depletion.

Thus, relying on technical solution alone can be risky. If dramatic technical progress does not take place, life style changes are inevitable if we want sustainable development. Also if you recognise the benefits, the costs of mitigation would not look too high.

It shows a mitigation supply curve and a set of mitigation demand curves. If one is interested primarily in removal of distorting subsidies then D 1 may be the demand curve. If in addition, the society cares to control local air pollution, the relevant demand curve would be D 2, and so on to D 5, which adds an ethical dimension on species loss. A society's willingness would improve with greater awareness of its citizens. All countries need to put in efforts to increase it.

BENEFITS JUSTIFY MITIGATION COST

Demand for Abatement If primary concern is D 1 Removal of distorting subsidies D2D1 + local air pollution D3D2 + local externalities *e.g.*, congestion D4D3 + ecosystem damage D5D4 + species loss.

The CDM – A Step towards Equity?

The Clean Development Mechanism (CDM) proposed in the Kyoto Protocol offers developing countries finance and technology by allowing countries to offset emissions through investing in emissions reduction in developing countries. Apart from the generally recognized problems of appropriate determination of the base line, India's concerns relate to getting fair compensation for sink projects, ensuring real transfer of technology and an uneasiness about selling 'low hanging fruits', *i.e.*, the exploitation of cheap emissions reduction early on in the process by developed countries.

Sink Projects through CDM t is generally believed that the sink projects such as growing trees for afforestation and so on are some of the most attractive options. India has some 100 million hectares of wasteland and degraded forests on which such projects may be started. However, several major considerations may be important.

(a) The trees fix carbon only during the growing periods. After reaching maturity, they are carbon- neutral. Thus, the carbon sink projects can create liabilities for the host country through committed land use.

(b) If at the end of maturity forests are removed, it may appear in the statistics of land use change of India. If the wood is burnt, will the CO_2 generated be the liability of India?

(c) If the forests are left intact, it may have implications if the opportunity costs of land become high in the meantime. However, only if the country had taken a careful long term decision to create green cover on a permanent basis, may such projects be considered. In the cases where the forest is removed or burnt, the global environment does not benefit as it would have merely postponed the problem. The liabilities are reduced only if energy crops are grown that will replace fossil fuels, for example, for wood based methanol, or wood-based power generation. However, who claims the credit, the one who supported the plantation or the one who uses it to replace fossil fuels?

(d) Another difficulty relates to the measurement of carbon sequestered. This is not an easy task. All kinds of fudging are possible and there would be incentives to do so. One may also note that afforestation projects involve very little technology and hence very little technology transfer. Technology transfer is claimed to be a major advantage of the CDM.

Technology Transfer (TT) and CDM TT and CDM should be linked to ensure wider adoption of environmentally beneficial technologies beyond the CDM project. India would like to see that a "CDM project" leads to real technology transfer giving the country the ability not only to operate the technology but also to replicate and innovate.

Another concern of India is pricing of technology. There should be competition here. In a bilateral deal, the supplier of technology has monopoly power and the price charged for technology may be too high. Also projects such as sequestration projects do not involve technology transfer.

One way to ensure that CDM projects involve technology transfer at competitive prices is to require that every CDM project, including sequestration projects, make a specific contribution to a technology acquisition fund with which the developing country is free to buy technology not necessarily related to the CDM project, from anywhere in the world. This can moderate excessively high charges for technology from a monopolist supplier.

LOW HANGING FRUITS AND PRICING OF CARBON

When carbon is traded, what developing countries gain would depend on whether the market is competitive, whether futures markets exist, or whether the carbon is bilaterally traded in a project-by- project basis, as is envisaged under CDM.

CARBON TRADING

As the developing countries have many low-cost opportunities to save GHG emissions (the low-hanging fruit) their marginal cost curve is relatively flat. Painuly has argued that developing countries are likely to get only about 20 % of the total surplus even under a competitive market. Should the developing countries then not opt for such trading? That would be an erroneous conclusion. If technical progress in the future lowers the demand drastically these low-hanging fruits would bring developing countries even less in future. The low-hanging fruits would then appear to just have rotten.

And in any case, since everybody tends to discount the future, money now is better than the same amount of money in future. However, developing countries can use these low-hanging fruits themselves in the future. So their long term opportunity cost may be higher than the short run marginal cost. To account for such opportunity costs, we should insist on the development of a futures market, so one can know how much the low-hanging fruits are going to be worth in the future.

Total Emission Reduction Commitment of A India is concerned that in bilateral negotiations between project parties, Indian entrepreneurs might only look at their private gain and sell carbon at throw-away prices, getting only AA'B. Developing countries should resist such trade. A well functioning market along with a futures market is the best way to ensure a good price. Development of such a market will take time. Meanwhile, a global carbon price floor should be announced for emissions trading and all developing countries should not trade below this price. India may want to do so unilaterally for its own projects.

TOWARDS A COMPREHENSIVE EARLY AGREEMENT

Disappointing delays in the implementation of the Kyoto Protocol lead us to suggest a system where all countries should be accountable for their cumulated emissions, say after 1990. When final negotiations are concluded, those countries that have taken early action will be rewarded and the others will have to do a lot more later.

We suggest the following: Despite the uncertainties surrounding climate change, the risks of potentially adverse impacts on the food system, coastal zones and increased occurrence of extreme events should be avoided by early action. Even during the negotiation period, an immediate decision to work from cumulative emissions for each country from a given year, say 1990 or 2000, should be taken.

That is, whatever the final negotiated strategy, it will be applicable from the agreed reference year in the past to reward early actions by any country and perhaps to conclude negotiations faster. Delay to implement such a system only rewards current high emitters who do not take action to reduce emissions. Suppose we agree to limit climate change to 2 degree C of temperature increase. To give countries some leeway to deal with uncertainties involved and their differing perspectives of risk, countries must be held accountable for the damages caused due to their cumulative emissions over the most pessimistic scenario (*i.e.*, one which restricts the atmospheric CO2 level to the lower value for such a temperature increase).

However, a country may be permitted to emit up to their quotas as per the scenarios they consider reasonable. *Over time with research and better understanding of the global climate system the uncertainty will reduce and estimates of* the range of emissions *required* to restrict warming to 2C will narrow. Participating countries would be held responsible for the emissions that correspond to narrowed range. For greater flexibility quotas should be leaseable.

There are many desirable consequences of such a system. It will optimise response and reduce free-riding through delay. We have observed that the cost of delay in emission reduction (by the North) in terms of the South's foregone opportunities to development is substantial. This will impose many constraints on the way the South decides on policy options regarding issues such as how to generate power, how to use land, and what crops to grow and so on. Moreover, the South is highly vulnerable to the impact of climate change.

Hence, unless the North acts now, North-South transfers of large amounts will be needed to compensate the South for the development opportunities foregone or for direct economic losses stemming from climate change. The risks to poor countries should be the primary focus of the climate change analysis, rather than costs to the developed countries. To this extent, a paradigm shift is necessary from the cost- minimization in the future analyses of IPCC.

Our main arguments are as follows: India and other developing countries feel strongly that they are not responsible for the threat of climate change that has been created. Unsustainable consumption patterns of the rich industrialised nations in the world are responsible for it. Yet, India and other developing country economies may be highly vulnerable to climate change.

India's food production would be adversely affected. Sea level rise would displace a large number of people. The developing countries are particularly vulnerable to the likely increase in the incidence of extreme events. The impacts

of climate change could hinder development and delay progress in eradicating poverty, potentially aggravating social and environmental conditions in these countries. An analysis of India's emissions show that its per capita emission of carbon is one fourth of the global average.

Even the top 10% of urban population emits well below the global average per capita emission. India, and other similar types of developing countries, are making significant progress in limiting GHG emissions through normal policy developments such as those aiming to improve energy and economic efficiency of the energy and industrial production capacity, as well as energy development, both conventional and renewable, which target improved environmental quality and limit human health hazards from air pollution.

India's energy intensity in industry and transport sector has come down. It has installed 2300 MW of generating capacity based on various renewables. Deforestation is arrested and the vast potential of afforestation on wasteland is increasingly utilised. India and many developing countries have carried out price reforms and removed subsidies.

These have resulted in substantial energy savings and reduction in emissions through greater use efficiency and fuel substitution. An equitable climate regime will focus on limiting the risks from climate change impacts to poor developing countries rather than on limiting the costs of mitigation per se. Options that improve economic efficiency of mitigation also need to address the distribution of economic costs associated with climate change. Such a system needs to be guided by a better understanding of the potential economic impacts and other risk to developing countries which emanate from the climate change problem. One must also recognise the need for economic growth of developing countries. With differentiated responsibility, countries have to take the lead. For a smooth transition, they should first stabilise their carbon emissions as soon as possible and then reduce them to sustainable levels over the coming decades.

Emission of developing countries will need to grow even at increasing rates for some time. They would have to stabilize them somewhat later in the future and then reduce them. Unfortunately countries are delaying action. By their delay, they are occupying global environmental space and are free riding on developing countries. Compared to the carbon emission that OECD countries would have made had they followed the FCCC agreed on at Rio, they have emitted much more.

In fact, even if they were to meet the Kyoto targets by 2012, the additional emission of OECD countries between 1992 and 2012, exceeds the emission **India** is likely to make over 40 years assuming a 5% growth rate of emission. Delay cannot be justified on the ground that the future generations would be richer and should, therefore, bear higher costs of mitigation.

Countries should use a low discount rate when assessing optimal mitigation strategies as postponing action now would put a larger burden of future population of developing countries – who would be poorer than what the citizens of countries are today. If countries recognise the environmental, societal and

ecosystem benefits of mitigation and value them properly, it would justify incurring large mitigation costs. We need to increase awareness of citizens. One promising option for organising mitigation over the long term is to hold countries accountable for all emissions from some fixed date in time, say 1990 or 2000.

This provides incentives for early conclusion of negotiation. The CDM could be risky for developing countries because of perverse incentives to exaggerate valid credits (*e.g.*, through exaggerated baselines) and because of likely imbalances in the power among the investor and host parties who will need to negotiate about important variables (*e.g.*, type of project, baseline, credit sharing and possibly price or other terms of reference for the investor). To equitably share the gains from CDM projects, we may start with fixing a global carbon price floor. A major attraction of the CDM for developing counties is technology transfer.

However, carbon sequestration projects do not involve any significant technology. Also the price at which monopolist suppliers provide technology may vary. We suggest a technology acquisition fund in which every CDM project, including sequestration project, is required to make a contribution to technology funds with which technology catering to specific needs of developing countries can be developed (for example, 2 wheelers transport with 4 stroke engines or certain cheap cooling equipment).

Moreover, the developing country should be free to choose technology, not necessarily from the country that brings the CDM project, but from anywhere in the world. A more interesting option over the longer term could be to go to a fully fledged emission trading system, which would increase the economic efficiency of long term mitigation and, if emission quotas are allocated in an equitable way, begin to compensate developing countries for any costs that significant mitigation might impose on their developing economies.

Many persons in India and other developing countries are concerned about selling off their cheap mitigation options (the 'low-hanging fruits'). One should weigh the price one gets today, the worth of such fruits in the future and the possibilities of their 'rotting' if unused. The need for an approach to mitigating the threat of climate change that is equitable and one that can accommodate differing perspectives on risk need to be elaborated.

To initiate action now even with differing perspectives of uncertainties and risks that different countries have, we suggest a scheme where a global trading system of carbon emissions with futures market is introduced. The allocations of quotas are made on an equitable basis.

However, the total quota will depend upon each country's subjective trajectory that restricts global temperature change to a desired limit, say 2 degree C. Countries, however, are responsible for their cumulative emissions in carbon-ton-years that they have made and the range of permissible trajectories narrows as our knowledge and understanding improve.

In the context of the current debate about climate change, it is necessary to show that far from being inactive, the developing countries, especially India, are

taking considerable actions in terms of policies, programmes and projects. Technology transfer can speed up the modernisation process and additional funds can accelerate Government initiatives in energy conservation. However, policies for poverty alleviation must take priority. It is shown that savings in GHG emissions by the poor should not be expected at the expense of development.

Yet, other savings by developing countries can be increased by technology transfer, investment in better infrastructure, and efforts for modernisation, all of which require financial support. Encouragement to conservation and good practices would result in lower emissions. Far from free riding, low GHG emissions in developing countries have made it possible to sustain the high pattern of energy consumption by the industrialised countries for decades in the past, at present and in the future too.

RISK OF LOWER AGRICULTURAL PRODUCTION

The FCCC objective states that GHG concentrations should be stabilised at levels where food production is not threatened. Thus, by examining the impact on agriculture of different climate change scenarios, one can get an idea of what is tolerable. Rosenzweig and Parry have estimated significant adverse impact on the agriculture of many developing countries.

In a more detailed study of India, Kumar and Parikh examined the impact of climate change on agricultural crop yields, GDP and welfare. Considering a range of equilibrium climate change scenarios which project a temperature rise of 2.5 o C to 4.9 o C for India, Kumar and Parikh estimated that:

1. Without considering the carbon dioxide fertilization effects yield losses for rice and wheat vary between 32 and 40%, and 41 and 52%, respectively;
2. GDP would drop by between 1.8 to 3.4%.

Their study also showed that even with carbon fertilization effects, losses would be in the same direction but somewhat smaller. Using an alternative methodology Kumar and Parikh showed that even with farm-level adaptations, the impacts of climate change on Indian agriculture would remain significant.

They estimated that with a temperature change of +2°C and an accompanying precipitation change of +7 %, farm level total net-revenue would fall by 9%, whereas with a temperature increase of +3.5°C and precipitation change of +15%, the fall in farm level total net-revenue would be nearly 25 %.

For a developing country, these are very large changes which can cause much human misery. From India's point of view, a 2°C increase would be clearly intolerable. Other developing countries may be even more vulnerable (possibly Bangladesh or Small Island States).

Risk of Sea Level Rise

Large-scale emigration from coastal zones is expected due to submergence of coast-lines after sea levels have risen. This will create large numbers of environmental refugees especially from low-lying delta regions in poor countries.

Furthermore, intrusion of sea-water in the ground water and changes in temperature can reduce agricultural and fishing incomes. Countries dependent on coastal fishery and agriculture, which most often include developing countries, are likely to be adversely affected. If a one-meter sea level rise were to take place today, it would displace 7 million persons in India. In the future many more may be displaced. 35% of the land in Bangladesh would be submerged by a one-meter rise.

The estimates for costs to build walls along the zones vulnerable to sea level rise for the USA is $107 billion in 1989 prices. That may be a small share of the GDP of developed countries, but such measures, even scaling for their coast lines, for say, Bangladesh, could require a very large share of its GDP.

Who shall pay Bangladesh or India for such a wall? Given that these countries are unlikely to be able to pay for protective measures, tens of millions of people will be displaced in Bangladesh and many of them could spill over into India.

ENVIRONMENTAL POLLUTION EFFECTS ON HUMANS

We know that pollution causes not only physical disabilities but also psychological and behavioural disorders in people. We are discussing the effects of air pollution and specific air pollutants in more detail in the Air Pollutants article. The following pollution effects on humans have been reported:

AIR POLLUTION EFFECTS

- Reduced lung functioning
- Irritation of eyes, nose, mouth and throat
- Asthma attacks
- Respiratory symptoms such as coughing and wheezing.
- Increased respiratory disease such as bronchitis
- Reduced energy levels
- Headaches and dizziness
- Disruption of endocrine, reproductive and immune systems
- Neurobehavioral disorders
- Cardiovascular problems
- Cancer
- Premature death.

WATER POLLUTION EFFECTS

Waterborne diseases caused by polluted drinking water:

- Typhoid
- Amoebiasis
- Giardiasis
- Ascariasis
- Hookworm.

Waterborne diseases caused by polluted beach water:

- Rashes, ear ache, pink eye
- Respiratory infections.
- Hepatitis, encephalitis, gastroenteritis, diarrhoea, vomiting, and stomach aches.

Conditions related to water polluted by chemicals (such as pesticides, hydrocarbons, persistent organic pollutants, heavy metals etc):

- Cancer, incl. prostate cancer and non-Hodgkin's lymphoma
- Hormonal problems that can disrupt reproductive and developmental processes
- Damage to the nervous system
- Liver and kidney damage
- Damage to the DNA
- Exposure to mercury (heavy metal):
  - *In the womb:* may cause neurological problems including slower reflexes, learning deficits, delayed or incomplete mental development, autism and brain damage
  - *In adults:* Parkinson's disease, multiple sclerosis, Alzheimer's disease, heart disease, and even death.

Other notes:

- Water pollution may also result from interactions between water and contaminated soil, as well as from deposition of air contaminants (such as acid rain)
- Damage to people may be caused by fish foods coming from polluted water (a well known example is high mercury levels in fish)
- Damage to people may be caused by vegetable crops grown/washed with polluted water (author's own conclusion).

SOIL POLLUTION EFFECTS

- Causes cancers including leukaemia
- Lead in soil is especially hazardous for young children causing developmental damage to the brain
- Mercury can increase the risk of kidney damage; cyclodienes can lead to liver toxicity
- Causes neuromuscular blockage as well as depression of the central nervous system
- Also causes headaches, nausea, fatigue, eye irritation and skin rash.

Other notes:

- Contact with contaminated soil may be *direct* (from using parks, schools etc) or *indirect* (by inhaling soil contaminants which have vaporized)
- Soil pollution may also result from secondary contamination of water supplies and from deposition of air contaminants (for example, via acid rain)

- Contamination of crops grown in polluted soil brings up problems with food security
- Since it is closely linked to water pollution, many effects of soil contamination appear to be similar to the ones caused by water contamination.

AN EXTREME OIL POLLUTION CASE

Pollution of pristine Ecuador rainforest by Texaco/Chevron oil corporation represents perhaps one of the most outrageous cases of oil pollution ever.

Some levels of pollutants left by the company on its sites of oil exploration have been calculated to exceed the US safety standards by as much as 1,000 times, causing such side effects as children born with fused fingers and deformed eyes, high cancer rates, *etc.*

ENVIRONMENTAL POLLUTION EFFECTS ON ANIMALS

- *Acid rain* (formed in the air) destroys fish life in lakes and streams
- Excessive *ultraviolet radiation* coming from the sun through the ozone layer in the upper atmosphere which is eroded by some air pollutants, may cause skin cancer in wildlife
- *Ozone* in the lower atmosphere may damage lung tissues of animals.

EFFECTS OF POLLUTION ON ANIMALS - WATER POLLUTION

- *Nutrient pollution* (nitrogen, phosphates etc) causes overgrowth of toxic algae eaten by other aquatic animals, and may cause death; nutrient pollution can also cause outbreaks of fish diseases
- *Chemical contamination* can cause declines in frog biodiversity and tadpole mass
- *Oil pollution* (as part of chemical contamination) can negatively affect development of marine organisms, increase susceptibility to disease and affect reproductive processes; can also cause gastrointestinal irritation, liver and kidney damage, and damage to the nervous system
- *Mercury* in water can cause abnormal behaviour, slower growth and development, reduced reproduction, and death
- *Persistent organic pollutants* (POPs) may cause declines, deformities and death of fish life
- Too much sodium chloride (ordinary salt) in water may kill animals.

EFFECTS OF POLLUTION ON ANIMALS - SOIL POLLUTION

- Can alter metabolism of microorganisms and arthropods in a given soil environment; this may destroy some layers of the primary food chain, and thus have a negative effect on predator animal species
- Small life forms may consume harmful chemicals which may then be passed up the food chain to larger animals; this may lead to increased mortality rates and even animal extinction.

ENVIRONMENTAL POLLUTION EFFECTS ON TREES AND PLANTS

AIR POLLUTION

- *Acid rain* can kill trees, destroy the leaves of plants, can infiltrate soil by making it unsuitable for purposes of nutrition and habitation
- *Ozone holes* in the upper atmosphere can allow excessive ultraviolet radiation from the sun to enter the Earth causing damage to trees and plants
- *Ozone* in the lower atmosphere can prevent plant respiration by blocking stomata (openings in leaves) and negatively affecting plants' photosynthesis rates which will stunt plant growth; ozone can also decay plant cells directly by entering stomata.

WATER POLLUTION

- May disrupt photosynthesis in aquatic plants and thus affecting ecosystems that depend on these plants
- Terrestrial and aquatic plants may absorb pollutants from water (as their main nutrient source) and pass them up the food chain to consumer animals and humans
- Plants may be killed by too much sodium chloride (ordinary slat) in water
- Plants may be killed by mud from construction sites as well as bits of wood and leaves, clay and other similar materials
- Plants may be killed by herbicides in water; herbicides are chemicals which are most harmful to plants.

SOIL POLLUTION

- May alter plant metabolism and reduce crop yields
- Trees and plants may absorb soil contaminants and pass them up the food chain.

ENVIRONMENTAL POLLUTION EFFECTS ON WIDER ENVIRONMENT

Apart from destroying the aquatic life in lakes and streams, acid rain can also corrode metals, damage surfaces of buildings and monuments, and cause soil acidification. Pollution of water may cause oxygen depletion in marine environments and severely affect the health of whole ecosystems.

ITS SOURCES AND EFFECTS

Environmental pollution is "the contamination of the physical and biological components of the earth/atmosphere system to such an extent that normal environmental processes are adversely affected". "Pollution is the introduction

of contaminants into the environment that cause harm or discomfort to humans or other living organisms, or that damage the environment" which can come "in the form of chemical substances, or energy such as noise, heat or light". "Pollutants can be naturally occurring substances or energies, but are considered contaminants when in excess of natural levels." Pollution is "the addition of any substance or form of energy (*e.g.*, heat, sound, radioactivity) to the environment at a rate faster than the environment can accommodate it by dispersion, breakdown, recycling, or storage in some harmless form". "Pollution is a special case of habitat destruction; it is chemical destruction rather than the more obvious physical destruction. Pollution occurs in all habitats—land, sea, and fresh water—and in the atmosphere."

"Much of what we have come to call pollution is in reality the nonrecoverable matter resources and waste heat." "Any use of natural resources at a rate higher than nature's capacity to restore itself can result in pollution of air, water, and land."

"Pollution is habitat contamination". Perhaps the overriding theme of these definitions is the ability of the environment to absorb and adapt to changes brought about by human activities.

In one word, environmental pollution takes place when the environment *cannot* process and neutralize harmful by-products of human activities (for example, poisonous gas emissions) *in due course* without any structural or functional damage to its system. In fact, "the due course" itself may last many years during which the nature will attempt to decompose the pollutants; in one of the worst cases – that of radioactive pollutants – it may take as long as thousands of years for the decomposition of such pollutants to be completed. Pollution occurs, on the one hand, because the natural environment does not know how to decompose the *un*naturally generated elements (*i.e.*, anthropogenic pollutants), and, on the other, there is a lack of knowledge on the part of humans on how to decompose these pollutants artificially.

WHY DOES POLLUTION MATTER?

It matters first and foremost because it has negative impacts on crucial environmental services such as provision of clean air and clean water (and many others) without which life on Earth as we know it would not exist.

AIR POLLUTION

As serious as water pollution is to the health and welfare of man, in many parts of the world air pollution represents an even more serious threat to human existence. Most of the major cities of the world and many rural areas as well now have serious air quality problems. The relative small (500,000 people) and modern capital of Malaysia, Kuala Lumpur, a beautiful city surrounded by luxuriant green hills, now has an emerging air pollution problem as its economy begins to prosper and expand. It arises from rapidly increasing automobile, truck and bus traffic, and burgeoning industrial development.

Even the remote capital of Nepal, Kathmandu, which is nestled in the Himalayan mountains north of India, began to show symptoms of air pollution in 1971. Famous for its clear mountain air and startling views of the high Himalaya, the valley of Kathmandu is often hazy with exhaust smoke from rapidly increasing automobile, truck, bus, and airplane traffic. The valley and city of Kathmandu are vulnerable to such pollution because of a natural air inversion a layer of warm tropical air over cold mountain air resting in an enclosed and densely populated valley. Unless control measures are taken now, the magnificent scenery which brings tourists to Nepal, will be viewed through a polluted haze in future years.

Ten years ago many engineers and environmental scientists insisted that there were few if any demonstrable ill effects on human health from the levels of air pollution then existing in most cities. They admitted exceptions to this, of course, but these were primarily confined to critical situations such as the famous London smog of 1952 in which 4,000 to 5,000 people died from respiratory distress in a persistent smog, or the crisis in Donora, Pennsylvania in 1948, in which hundreds of people suffered similar fatalities during and after a severe smog condition which hung over the city for several weeks. Other than these rare circumstances, there was little evidence that chronic levels of urban air pollution represented a public health problem.

Now there is abundant evidence that the levels of air pollution in many cities do represent a major medical problem. This evidence comes from both experimental research with animals and clinical studies in human health. In fact, the health hazards of air pollution in the United States, Japan and parts of Europe are now more clearly documented than are those of water pollution. This is not true, of course, throughout much of Latin America, Africa, and Asia, where impure water still represents a major health problem.

Some of the first clues to the health hazards of air pollution came from clinical observations of increasing rates of emphysema, chronic bronchitis, and respiratory distress in city dwellers, and from experimental studies on laboratory animals exposed to air pollutants. In the latter category of experimental studies, it was noted in Los Angeles several years ago that laboratory mice exposed to ambient air pollution (*i.e.*, normally existing air pollution) developed significant pathology compared to control mice in clean air. Aging inbred mice showed increased frequency of pulmonary adenoma, and one strain of rice showed increased mortality of young adult males. Severe smog episodes in Los Angeles caused basic changes in the cellular structure of lung tissue in these animals. Guinea pigs and rabbits developed altered hormone excretion patterns and differential enzyme levels in blood serum in contrast to clean air controls.

Pathologic effects of air pollution have also been clearly demonstrated in people. In one study in New York City, children under 8 years of age showed a prevalence of respiratory symptoms directly related to levels of particulate matter and carbon monoxide. In many cities along the Eastern seabord, increasing evidence of dyspnea, bronchitis, cough, sputum production, wheezes, eye

irritations and general malaise was elicited as air pollution levels increased. In Los Angeles, a correlation was shown between carbon monoxide pollution levels and case fatality rates in patients with heart trouble.

Sulfur dioxide is one of the common gaseous air pollutants which is most injurious to human health. It irritates respiratory epithelium and impairs normal beathing. Most cities have SO_2 levels less than 0.5 ppm, and human effects are not prominent until 0.8 or 1.0 ppm are attained. Frequently, ambient levels in cities exceed 0.8 ppm when stagnant air remains for several days and gaseous pollutants accumulate. Investigators have shown correlations between photochemical air pollutants and respiratory distress, emphysema and susceptibility to respiratory infection. Chronic as well as acute effects have been documented. In the industrial complex of Bayonne and Elizabeth, New Jersey, the death rate from respiratory cancer in males was 35 per cent higher in an area of high air pollution, compared to a similar population living in a lower air pollution environment only a few miles away.

On Staten Island, the rate of lung cancer in women in polluted areas was shown to be twice that of women in clear areas. Other studies have shown that urban air pollution increases the rate of lung cancer in men three times above that of rural men. This type of evidence could be cited in considerable detail to leave little doubt that air pollution is detrimental to human health. In fact, respiratory ailments related to air pollution—emphysema, chronic bronchitis, lung ancer, and severe asthma—are among the most rapidly increasing health problems in industrialized nations.

Various disease problems associated with air pollution were reviewed by Lave and Seskin who also evaluated the economic costs of respiratory disease attributable the air pollution. They estimated that a 50 per cent reduction in US urban air pollution would save the nation $2,080 million dollars per year in health and medical costs.

Air pollution is as complex in origin and type as water pollution. It has been estimated that 164 million metric tons of pollutants enter the United States air every year. This pollutant load is composed of a wide range of particulate matter, suspended particles, and gases. In New York City alone, the daily emission of air pollutants includes 3,200 tons of SO_2, 4,200 tons of CO, and 280 tons of particulate dirt. In Philadelphia in 1959, daily releases of air pollutants amounted to 830 tons of SO_2, 300 tons of NO_2, 1,350 tons of hydrocarbons, and 470 tons of particulates.

Particulate matter fall-out affords a dramatic example of dirty air. In many of the world's cities, the average daily air pollution fall-out is in the order 0.5 to 3.0 tons per square mile per day. Some cities have over 4 tons per square mile per day. In Pittsburgh, fall-out was reduced from over 5.5 tons per square mile per day to less than 0.9 tons by a vigorous clean air and smoke abatement programme. Up to one per cent of urban dust may be lead, which is toxic to humans in fairly low concentrations.

Yet particulate fall-out, while it may be one of the most dramatic forms of air pollution, is certainly not necessarily the most harmful. Most particles which

fall out are over 100 micra in diameter, and these seldom if ever reach the alveolar tissue of the lung where irritation occurs. Fine suspended particles and gaseous substances are the primary agents of respiratory distress.

One of the most persistent forms of air pollution which has not responded well to control measures is automobile exhaust. In the late 1960's, over 90 million motor vehicles in the United States produced 66 million tons of carbon monoxide, and 20 million tons of other air pollutants per year. Although various devices have been developed to reduce exhaust emission, these devices are not consistently well maintained by the public.

Los Angeles, which has mounted an outstanding campaign of industrial air pollution control, still faces a major smog problem from automobile exhaust. The city has 4,000,000 automobiles for 3,000,000 people.

Two-thirds of the area of the central city has been taken over by the automobile in the form of parking space, streets and freeways. One study in Los Angeles showed a direct correlation between air pollution and the frequency of motor vehicle accidents.

In the air on crowded freeways, carbon monoxide levels may reach 400 parts per million. Automobile drivers thought to be responsible for accidents showed elevated carbon monoxide levels in their blood. Many experts predict that the internal combustion engine must be either outlawed or significantly altered within the next few years if we are to avert air pollution tragedies in our cities.

There is no doubt that air pollution is a very significant and increasing factor in environmental deterioration. Airplane pilots who have flown for twenty or thirty years report a great increase in "ground haze" and air pollution domes encapsulating cities. Whereas cities were often seen from aerial distances of 30 to 40 miles some years ago, they are now usually enshrouded by air pollution and not visible from more than 5 or 10 miles.

In many areas, air pollution has caused dramatic injury to plants, both agricultural crops and natural plant communities. Citrus groves, truck garden crops of lettuce, tomatoes, onions and celery, field crops of alfalfa, sweet corn, and tobacco, and even forests of pine, spruce, and deciduous trees have all fallen victims to air pollution in various parts of the world. Air pollution also takes its toll of buildings and other man-made objects. When moisture accumulates in polluted air, the oxides of sulfur, carbon and nitrogen form weak sulfuric acid, carbonic acid and nitrous acid which are corrosive to metals, stone, paint, rubber, textiles and even some plastics. One study estimated that air pollution in 1960 cost the average American family $800 per year in property damage. Current projections of this figure would certainly put these costs well over $1000 per family per year.

Throughout Europe, many famous buildings, monuments and art treasures of former centuries are deteriorating at an alarming rate due to the erosional effects of air pollution. In Athens, the President of the Greek Academy of Sciences, estimated in 1971 that the Parthenon on top of the Acropolis has deteriorated more in the last 50 years than in the previous 2000 years. Athens is

normally blessed with clean fresh air, but this depends entirely on sea breezes. On still, windless days, a noxious air pollution haze quickly forms, even shrouding out the Aegean Sea near Pathens. A serious possibility of world-wide air pollution that was first detected in the late 1960s is the occurrence of stratospheric pollution and a global air pollution veil; that is, a ring of air pollution circling the globe in the northern hemisphere around the latitudes of the US, Europe and Japan.

Such a global veil has been detected by satellite photos, and confirmed by both Russian and US scientists. The formations have been temporary, and apparently occurred during periods of unusually stable currents of air circulation around the world. In other words, pollutants were being carried intercontinenally, so that air entering North America contained Japanese contaminants, and air entering Europe contained North American pollutants. Normally, the oceanic mixing of air would break up pollution bands. This is not a major problem now, but it is a serious portent of things to come.

Certainly, many types of air pollution can be controlled by modern technology, but the costs must ultimately be borne by the public through higher prices for industrial goods, higher taxes, reduced profit margins in industry, and more careful monitoring of automobile exhaust control systems. In many cases of environmental quality control, the ultimate responsibility rests with the citizenry at large through established routes of political process.

The present cost of air pollution in terms of ill health, agricultural damage, and accelerated deterioration of construction materials and personal goods is very great, but it is so diffuse and indirect that we are not aware of the great price we already are paying for it. When we reach the point where the cost of air pollution is greater than the cost of controlling it, the public must demand appropriate governmental action and be willing to support it.

WATER POLLUTION

Water pollution is a broad and generic term with a variety of meanings. It can, in fact, mean almost any type of aquatic contamination between two extremes:

1. A highly enriched overproductive biotic community, as a lake or river enriched with nitrates and phosphates from domestic sewage;
2. A biotic community with sufficient concentration of toxic substances to eliminate many forms of living organisms or even exclude all forms of life.

Types of water pollution may also be identified by the medium in which they occur (surface water, ground water, soil, *etc.*), the habitat in which they occur (marine, estuarine, river, *etc.*), or the source or type of contamination (nutrient, domestic, pesticide, thermal, industrial, *etc.*). One of the best definitions of pollution is. "Environmental pollution is the unfavourable alteration of our surroundings, wholly or largely as a by-product of man's actions, through direct or indirect effects of changes in energy patterns, radiation levels, chemical and physical constitution and the abundance organisms."

Pollutants of streams, lakes and estuaries come from many sources. Excessive nutrients commonly originate in domestic sewage and run-off from agricultural fertilizer. Certainly the former is the major source of excessive nutrients in most streams and lakes.

Toxic chemicals originate in industrial operations, acid waters from mine seepage or surface erosion, and washings of herbicides and insecticides.

SOURCES OF WATER POLLUTION

Principal sources of water pollution are:

- Industrial discharge of chemical wastes and byproducts
- Discharge of poorly-treated or untreated sewage
- Surface runoff containing pesticides
- Slash and burn farming practice, which is often an element within shifting cultivation agricultural systems
- Surface runoff containing spilled petroleum products
- Surface runoff from construction sites, farms, or paved and other impervious surfaces *e.g.*, silt
- Discharge of contaminated and/or heated water used for industrial processes
- Acid rain caused by industrial discharge of sulfur dioxide (by burning high-sulfur fossil fuels)
- Excess nutrients added by runoff containing detergents or fertilizers
- Underground storage tank leakage, leading to soil contamination, thence aquifer contamination.

CONTAMINANTS

Contaminants may include organic and inorganic substances.

Some organic water pollutants are:

- Insecticides and herbicides, a huge range of organohalide and other chemicals
- Bacteria, often is from sewage or livestock operations;
- Food processing waste, including pathogens
- Tree and brush debris from logging operations
- VOCs (Volatile Organic Compounds, industrial solvents) from improper storage

Some inorganic water pollutants include:

- Heavy metals including acid mine drainage
- Acidity caused by industrial discharges (especially sulfur dioxide from power plants)
- Chemical waste as industrial by products
- Fertilizers, in runoff from agriculture including nitrates and phosphates
- Silt in surface runoff from construction sites, logging, slash and burn practices or land clearing sites

TRANSPORT AND CHEMICAL REACTIONS OF WATER POLLUTANTS

Most water pollutants are eventually carried by the rivers into the oceans. In some areas of the world the influence can be traced hundred miles from the mouth by studies using hydrology transport models. Advanced computer models such as SWMM or the DSSAM Model have been used in many locations worldwide to examine the fate of pollutants in aquatic systems. Indicator filter feeding species such as copepods have also been used to study pollutant fates in the New York Bight, for example. The highest toxin loads are not directly at the mouth of the Hudson River, but 100 kilometers south, since several days are required for incorporation into planktonic tissue. The Hudson discharge flows south along the coast due to coriolis force. Further south then are areas of oxygen depletion, caused by chemicals using up oxygen and by algae blooms, caused by excess nutrients from algal cell death and decomposition. Fish and shellfish kills have been reported, because toxins climb the foodchain after small fish consume copepods, then large fish eat smaller fish, *etc.* Each step up the food chain concentrates certain toxins like heavy metals and DDT by approximately a factor of ten.

For several years ocean researcher Charles Moore has been investigating a concentration of floating plastic debris in the Pacific Ocean. His study indicates that ocean currents have added to the mass until it is now about the size of Texas. Many of these long-lasting pieces wind up in the stomachs of marine birds and animals.

Many chemicals undergo reactive decay or change especially over long periods of time in groundwater reservoirs. A noteworthy class of such chemicals are the chlorinated hydrocarbons such as trichloroethylene (used in industrial metal degreasing) and tetrachloroethylene used in the dry cleaning industry. Both of these chemicals, which are carcinogens themselves, undergo partial decomposition reactions leading to new hazardous chemicals.

Groundwater pollution is much more difficult to abate than surface pollution because groundwater can move great distances through unseen aquifers. Non-porous aquifers such as clays partially purify water of bacteria by simple filtration (adsorption and absorption), dilution, and, in some cases, chemical reactions and biological activity: however, in some cases, the pollutants merely transform to soil contaminants. Groundwater that moves through cracks and caverns is not filtered and can be transported as easily as surface water. In fact this can be aggravated by the human tendency to use natural sinkholes as dumps in areas of Karst topography.

There are a variety of secondary effects stemming not from the original pollutant, but a derivative condition. Some of these secondary impacts are:

- Silt bearing surface runoff from can inhibit the penetration of sunlight through the water column, hampering Photosynthesis in aquatic plants.
- Thermal pollution can induce fish kills and invasion by new thermophyllic species

EFFECTS OF EXCESSIVE NUTRIENTS

Even with modern sewage treatment plants, water pollution problems are not entirely avoided. Modern plants remove or inactivate bacteria from the effluent water, but such water is still rich in basic nutrients, such as ammonia, nitrogen, nitrates, nitrites and phosphates. Primary and secondary sewage plants do not remove these sources of pollution. Primary sewage treatment involves screening and sedimentation of solids; secondary treatment involves biological reduction of organic matter; only tertiary treatment removes nutrients. Such nutrients stimulate plant growth, often in the form of phytoplankton or algae.

The enriched waters are thus prone to plankton blooms which may have several undesirable consequences. Some plankton blooms, particularly those of the blue-green algae, produce undesirable odors and tastes in water. Others, such as the dinoflagellate blooms or redtide of the southern coastal regions, produce toxic metabolic products which can result in major fish kills. Plankton blooms of green algae do not necessarily produce undesirable odors or toxic products, but they can still create problems of oxygen supply in the water. While these blooms exist under abundant sunlight, they contribute oxygen to the water through photosynthesis, but under conditions of continued cloudiness, they consume more oxygen than they produce and lead to oxygen depletion in the waters. Thus, dissolved oxygen may decline rapidly from favourable levels of 10 to 12 ppm to unfavourable levels of 2 to 3 ppm in which fish experience distress and asphyxiation. Highly enriched streams just below sewage outfalls may show a severe reduction in fish populations, as was documented for the Patuxent River of Maryland. The Potomac River below Washington, DC is highly polluted with domestic sewage and has dissolved oxygen levels often less than 1 ppm. This portion of the river displays annual fish kills every May, when fish reach these oxygen-depleted waters during their spring migrations. Excessive nutrient levels in aquatic systems can cause two other kinds of ecologic consequences. They may lead to extensive growth of aquatic weeds such as Eurasian milfoil, water hyacinth, water chestnut, and many others which have become a worldwide problem. These growths may become so great as to impair fishing, bathing, fish spawning, shellfish production, and even navigation. Hence, excessive plant growths in enriched waters often represent a major economic problem as well as a complete disruption of aquatic ecology.

It has recently been demonstrated that excessive nutrients in water supplies, in the order of 8 or 9 ppm of nitrate nitrogen can cause human disease, as, for example, methemoglobinemia in infants. This is an illness caused by a modified form of normal oxyhemoglobin in the blood, resulting in inadequate oxygen transport by red cells and labored breathing.

IMPACT OF CLIMATE CHANGE ON AGRICULTURE

Despite technological advances, such as improved varieties, genetically modified organisms, and irrigation systems, weather is still a key factor in

agricultural productivity, as well as soil properties and natural communities. The effect of climate on agriculture is related to variabilities in local climates rather than in global climate patterns. The Earth's average surface temperature has increased by 1 degree F in just over the last century. Consequently, agronomists consider any assessment has to be individually consider each local area.

On the other hand, agricultural trade has grown in recent years, and now provides significant amounts of food, on a national level to major importing countries, as well as comfortable income to exporting ones. The international aspect of trade and security in terms of food implies the need to also consider the effects of climate change on a global scale.

A study published in *Science* suggests that, due to climate change, "southern Africa could lose more than 30% of its main crop, maize, by 2030. In South Asia losses of many regional staples, such as rice, millet and maize could top 10%".

The 2001 IPCC Third Assessment Report concluded that the poorest countries would be hardest hit, with reductions in crop yields in most tropical and sub-tropical regions due to decreased water availability, and new or changed insect pest incidence. In Africa and Latin America many rainfed crops are near their maximum temperature tolerance, so that yields are likely to fall sharply for even small climate changes; falls in agricultural productivity of up to 30% over the 21st century are projected. Marine life and the fishing industry will also be severely affected in some places.

Climate change induced by increasing greenhouse gases is likely to affect crops differently from region to region. For example, average crop yield is expected to drop down to 50% in Pakistan according to the UKMO scenario whereas corn production in Europe is expected to grow up to 25% in optimum hydrologic conditions.

More favourable effects on yield tend to depend to a large extent on realization of the potentially beneficial effects of carbon dioxide on crop growth and increase of efficiency in water use. Decrease in potential yields is likely to be caused by shortening of the growing period, decrease in water availability and poor vernalization. In the long run, the climatic change could affect agriculture in several ways:

- *Productivity*, in terms of quantity and quality of crops
- *Agricultural practices*, through changes of water use (irrigation) and agricultural inputs such as herbicides, insecticides and fertilizers
- *Environmental effects*, in particular in relation of frequency and intensity of soil drainage (leading to nitrogen leaching), soil erosion, reduction of crop diversity
- *Rural space*, through the loss and gain of cultivated lands, land speculation, land renunciation, and hydraulic amenities.
- *Adaptation*, organisms may become more or less competitive, as well as humans may develop urgency to develop more competitive organisms, such as flood resistant or salt resistant varieties of rice.

They are large uncertainties to uncover, particularly because there is lack of information on many specific local regions, and include the uncertainties on magnitude of climate change, the effects of technological changes on productivity, global food demands, and the numerous possibilities of adaptation.

Most agronomists believe that agricultural production will be mostly affected by the severity and pace of climate change, not so much by gradual trends in climate.

If change is gradual, there may be enough time for biota adjustment. Rapid climate change, however, could harm agriculture in many countries, especially those that are already suffering from rather poor soil and climate conditions, because there is less time for optimum natural selection and adaption.

PROJECTIONS

Schneider *et al.*. (2007:787) assessed the literature on key vulnerabilities to climate change. With low to medium confidence, they concluded that for about a 1 to 3°C global mean temperature increase (by 2100, relative to the 1990-2000 average level) there would be productivity decreases for some cereals in low latitudes, and productivity increases in high latitudes. With medium confidence, global production potential was predicted to:

- Increase up to around 3°C,
- Very likely decrease above about 3 to 4°C.

Most of the studies on global agriculture assessed by Schneider *et al.*. (2007:790) had not incorporated a number of critical factors, including changes in extreme events, or the spread of pests and diseases. Studies had also not considered the development of specific practices or technologies to aid adaptation.

REGIONAL

- *Africa:*
  - — Africa's geography makes it particularly vulnerable to climate change, and seventy per cent of the population rely on rain-fed agriculture for their livelihoods. Tanzania's official report on climate change suggests that the areas that usually get two rainfalls in the year will probably get more, and those that get only one rainy season will get far less. The net result is expected to be that 33% less maize—the country's staple crop—will be grown. Alongside other factors, regional climate change-in particular, reduced precipitation-is thought to have contributed to the conflict in Darfur. The combination of decades of drought, desertification and overpopulation are among the causes of the conflict, because the Baggara Arab nomads searching for water have to take their livestock further south, to land mainly occupied by farming peoples.
  - — With high confidence, IPCC (2007:13) concluded that climate variability and change would severely compromise agricultural production and access to food.

- *Asia:* With medium confidence, IPCC (2007:13) projected that by the mid-21st century, in East and Southeast Asia, crop yields could increase up to 20%, while in Central and South Asia, yields could decrease by up to 30%. Taken together, the risk of hunger was projected to remain very high in several developing countries. More detailed analysis of rice yields by the International Rice Research Institute forecast 20% reduction in yields over the region per degree Celsius of temperature rise. Rice becomes sterile if exposed to temperatures above 35 degrees for more than one hour during flowering and consequently produces no grain.
- *Australia and New Zealand:* Hennessy *et al.*. (2007:509) assessed the literature for this region. They concluded that without further adaptation to climate change, projected impacts would likely be substantial: By 2030, production from agriculture and forestry was projected to decline over much of southern and eastern Australia, and over parts of eastern New Zealand; In New Zealand, initial benefits were projected close to major rivers and in western and southern areas. Hennessy *et al.*. (2007:509) placed high confidence in these projections.
- *Europe:* With high confidence, IPCC (2007:14) projected that in Southern Europe, climate change would reduce crop productivity. In Central and Eastern Europe, forest productivity was expected to decline. In Northern Europe, the initial effect of climate change was projected to increase crop yields.
- *Latin America:* With high confidence, IPCC (2007:14) projected that in drier areas of Latin America, productivity of some important crops would decrease and livestock productivity decline, with adverse consequences for food security. In temperate zones, soybean yields were projected to increase.
- *North America:*
  - — According to a paper by Deschenes and Greenstone (2006), predicted increases in temperature and precipitation will have virtually no effect on the most important crops in the US.
  - — With high confidence, IPCC (2007:14-15) projected that over the first few decades of this century, moderate climate change would increase aggregate yields of rain-fed agriculture by 5–20%, but with important variability among regions. Major challenges were projected for crops that are near the warm end of their suitable range or which depend on highly utilized water resources.
- *Polar regions (Arctic and Antarctic):*
  - — For the *Guardian* newspaper, Brown (2005) reported on how climate change had affected agriculture in Iceland. Rising temperatures had made the widespread sowing of barley possible, which had been untenable twenty years ago. Some of the warming was due to a local (possibly temporary) effect via ocean currents from the Caribbean, which had also affected fish stocks.

— Anisimov *et al.*. (2007:655) assessed the literature for this region. With medium confidence, they concluded that the benefits of a less severe climate were dependent on local conditions. One of these benefits was judged to be increased agricultural and forestry opportunities.

- *Small islands:* In a literature assessment, Mimura *et al.*. (2007:689) concluded, with high confidence, that subsistence and commercial agriculture would very likely be adversely affected by climate change.

SHORTAGE IN GRAIN PRODUCTION

Between 1996 and 2003, grain production has stabilized slightly over 1800 millions of tons. In 2000, 2001, 2002 and 2003, grain stocks have been dropping, resulting in a global grain harvest that was short of consumption by 93 millions of tons in 2003. The Earth's average temperature has been rising since the late 1970s, with nine of the 10 warmest years on record occurring since 1995. In 2002, India and the United States suffered sharp harvest reductions because of record temperatures and drought. In 2003 Europe suffered very low rainfall throughout spring and summer, and a record level of heat damaged most crops from the United Kingdom and France in the Western Europe through Ukraine in the East. Bread prices have been rising in several countries in the region.

POVERTY IMPACTS

Researchers at the Overseas Development Institute (ODI) have investigated the potential impacts climate change could have on agriculture, and how this would affect attempts at alleviating poverty in the developing world. They argued that the effects from moderate climate change are likely to be mixed for developing countries. However, the vulnerability of the poor in developing countries to short term impacts from climate change, notably the increased frequency and severity of adverse weather events is likely to have a negative impact. This, they say, should be taken into account when defining agricultural policy.

CROP DEVELOPMENT MODELS

Models for climate behaviour are frequently inconclusive. In order to further study effects of global warming on agriculture, other types of models, such as *crop development models*, *yield prediction*, quantities of *water or fertilizer consumed*, can be used. Such models condense the knowledge accumulated of the climate, soil, and effects observed of the results of various agricultural practices. They thus could make it possible to test strategies of adaptation to modifications of the environment.

Because these models are necessarily simplifying natural conditions (often based on the assumption that weeds, disease and insect pests are controlled), it is not clear whether the results they give will have an *in-field* reality. However, some results are partly validated with an increasing number of experimental

results. Other models, such as *insect and disease development* models based on climate projections are also used (for example simulation of aphid reproduction or septoria (cereal fungal disease) development).

Scenarios are used in order to estimate climate changes effects on crop development and yield. Each scenario is defined as a set of meteorological variables, based on generally accepted projections. For example, many models are running simulations based on doubled carbon dioxide projections, temperatures raise ranging from 1°C up to 5°C, and with rainfall levels an increase or decrease of 20%. Other parameters may include humidity, wind, and solar activity. Scenarios of crop models are testing farm-level adaptation, such as sowing date shift, climate adapted species (vernalisation need, heat and cold resistance), irrigation and fertilizer adaptation, resistance to disease. Most developed models are about wheat, maize, rice and soybean.

AGRICULTURAL SURFACES AND CLIMATE CHANGES

Climate change may increase the amount of arable land in high-latitude region by reduction of the amount of frozen lands. A 2005 study reports that temperature in Siberia has increased three degree Celsius in average since 1960 (much more than the rest of the world). However, reports about the impact of global warming on Russian agriculture indicate conflicting probable effects: while they expect a northward extension of farmable lands, they also warn of possible productivity losses and increased risk of drought.

Sea levels are expected to get up to one meter higher by 2100, though this projection is disputed. A rise in the sea level would result in an agricultural land loss, in particular in areas such as South East Asia. Erosion, submergence of shorelines, salinity of the water table due to the increased sea levels, could mainly affect agriculture through inundation of low-lying lands. Low lying areas such as Bangladesh, India and Vietnam will experience major loss of rice crop if sea levels are expected to rise by the end of the century. Vietnam for example relies heavily on its southern tip, where the Mekong Delta lies, for rice planting. Any rise in sea level of no more than a meter will drown several km^2. of rice paddies, rendering Vietnam incapable of producing its main staple and export of rice.

EROSION AND FERTILITY

The warmer atmospheric temperatures observed over the past decades are expected to lead to a more vigorous hydrological cycle, including more extreme rainfall events. Erosion and soil degradation is more likely to occur. Soil fertility would also be affected by global warming. However, because the ratio of carbon to nitrogen is a constant, a doubling of carbon is likely to imply a higher storage of nitrogen in soils as nitrates, thus providing higher fertilizing elements for plants, providing better yields. The average needs for nitrogen could decrease, and give the opportunity of changing often costly fertilization strategies.

Due to the extremes of climate that would result, the increase in precipitations would probably result in greater risks of erosion, whilst at the same time providing soil with better hydration, according to the intensity of the rain. The possible evolution of the organic matter in the soil is a highly contested issue: while the increase in the temperature would induce a greater rate in the production of minerals, lessening the soil organic matter content, the atmospheric CO_2 concentration would tend to increase it.

POTENTIAL EFFECTS OF GLOBAL CLIMATE CHANGE

A very important point to consider is that weeds would undergo the same acceleration of cycle as cultivated crops, and would also benefit from carbonaceous fertilization. Since most weeds are C3 plants, they are likely to compete even more than now against C4 crops such as corn. However, on the other hand, some results make it possible to think that weedkillers could gain in effectiveness with the temperature increase. Global warming would cause an increase in rainfall in some areas, which would lead to an increase of atmospheric humidity and the duration of the wet seasons. Combined with higher temperatures, these could favour the development of fungal diseases. Similarly, because of higher temperatures and humidity, there could be an increased pressure from insects and disease vectors.

GLACIER RETREAT AND DISAPPEARANCE

The continued retreat of glaciers will have a number of different quantitative impacts. In areas that are heavily dependent on water runoff from glaciers that melt during the warmer summer months, a continuation of the current retreat will eventually deplete the glacial ice and substantially reduce or eliminate runoff. A reduction in runoff will affect the ability to irrigate crops and will reduce summer stream flows necessary to keep dams and reservoirs replenished. Approximately 2.4 billion people live in the drainage basin of the Himalayan rivers. India, China, Pakistan, Afghanistan, Bangladesh, Nepal and Myanmar could experience floods followed by severe droughts in coming decades. In India alone, the Ganges provides water for drinking and farming for more than 500 million people. The west coast of North America, which gets much of its water from glaciers in mountain ranges such as the Rocky Mountains and Sierra Nevada, also would be affected.

OZONE AND UV-B

Some scientists think agriculture could be affected by any decrease in stratospheric ozone, which could increase biologically dangerous ultraviolet radiation B. Excess ultraviolet radiation B can directly effect plant physiology and cause massive amounts of mutations, and indirectly through changed pollinator behaviour, though such changes are simple to quantify. However, it has not yet been ascertained whether an increase in greenhouse gases would decrease stratospheric ozone levels. In addition, a possible effect of rising temperatures is significantly higher levels of ground-level ozone, which would substantially lower yields.

ENSO EFFECTS ON AGRICULTURE

ENSO (El Niño Southern Oscillation) will affect monsoon patterns more intensely in the future as climate change warms up the ocean's water. Crops that lie on the equatorial belt or under the tropical Walker circulation, such as rice, will be affected by varying monsoon patterns and more unpredictable weather. Scheduled planting and harvesting based on weather patterns will become less effective.

Areas such as Indonesia where the main crop consists of rice will be more vulnerable to the increased intensity of ENSO effects in the future of climate change.

University of Washington professor, David Battisti, researched the effects of future ENSO patterns on the Indonesian rice agriculture using [IPCC]'s 2007 annual report and 20 different logistical models mapping out climate factors such as wind pressure, sea-level, and humidity, and found that rice harvest will experience a decrease in yield. Bali and Java, which holds 55% of the rice yields in Indonesia, will be likely to experience 9-10% probably of delayed monsoon patterns, which prolongs the hungry season. Normal planting of rice crops begin in October and harevest by January. However, as climate change affects ENSO and consequently delays planting, harvesting will be late and in drier conditions, resulting in less potential yields.

7

Advances in Environmental Science and Applications

The science of earth and environment has matured through two major phases and is entering a third. In the first phase, which ended two decades ago, Earth and environmental science was largely discipline oriented and focused on developing knowledge in geology, atmospheric chemistry, ecosystems, and other aspects of the Earth system. In the 1980s, the scientific community recognized the close coupling of these disciplines and began to study them as interacting elements of a single system.

During this second phase, the paradigm of Earth system science emerged. With it came the ability to understand complex, system-oriented phenomena such as climate change, which links concepts from atmospheric sciences, biology, and human behaviour. Essential to the study of Earth's interacting systems was the ability to acquire, manage, and make available data from satellite observations; in parallel, new models were developed to express our growing understanding of the complex processes in the dynamic Earth system.

In the emerging third phase, knowledge developed primarily for the purpose of scientific understanding is being complemented by knowledge created to target practical decisions and action.

This new knowledge endeavor can be referred to as the science of environmental applications. Climate change provides the most prominent example of the importance of this shift. Until now, the climate science community has focused on critical questions involving basic knowledge, from measuring the amount of change to determining the causes.

With the basic understanding now well established, the demand for climate applications knowledge is emerging. How do we quantify and monitor total forest biomass so that carbon markets can characterize supply? What are the implications of regional shifts in water resources for demographic trends, agricultural output, and energy production?

To what extent will seawalls and other adaptations to rising sea level impact coasts? These questions are informed by basic science, but they raise additional issues that can be addressed only by a new science discipline focused specifically on applications- a discipline that integrates physical, biogeochemical, engineering, and human processes. Its principal questions reflect a fundamental curiosity about the nature of the world we live in, tempered by the awareness that a question's importance scales with its relevance to a societal imperative. As Nobel laureate and U.S.

Secretary of Energy Steven Chu has remarked, "We seek solutions. We don't seek- dare I say this?-just scientific papers anymore". To illustrate the relationships between basic science and applications, consider the role of snowmelt runoff in water supplies. Worldwide, 1 billion people depend on snow or glacier melt for their water resources. Design and operations of water systems have traditionally relied on historical measurements in a stationary climate, along with empirical relationships and models. As climates and land use change, populations grow and relocate, and our built systems age and decay, these empirical methods of managing our water become inaccurate-a conundrum characterized as "stationarity is dead".

Snowmelt commonly provides water for competing uses: urban and agricultural supply, hydropower, recreation, and ecosystems. In many areas, both rainfall and snowfall occur, raising the concern that a future warmer climate will lead to a greater fraction of precipitation as rain, with the water arriving months before agricultural demand peaks and with more rapid runoff leading to more floods. In these mixed rain and snow systems, the societal need is: How do we sustain flood control and the benefits that water provides to humans and ecosystems when changes in the timing and magnitude of runoff are likely to render existing infrastructure inadequate?

The solution to the societal need requires a more fundamental, process-based understanding of the water cycle. Currently, historical data drive practices and decisions for flood control and water supply systems. Flood operations and reservoir flood capacity are predetermined by regulatory orders that are static, regardless of the type of water year, current state of the snowpack, or risk of flood. In many years, early snowmelt is not stored because statistically based projections anticipate floods that better information might suggest cannot materialize because of the absence of snow. The more we experience warming, the more frequently this occurrence will impact the water supply.

The related science challenges are:

- The statistical methods in use do not try to estimate the basin’s water balance, and with the current measurement networks even in the U.S., we lack adequate knowledge of the amount of snow in the basins;

- We are unable to partition the input between rain and snow, or to partition that rain or snow between evapotranspiration and runoff;
- We lack the knowledge to manage the relationship between snow cover, forests, and carbon stocks;
- Runoff forecasts that are not based on physical principles relating to snowmelt are often inaccurate;
- We do not know what incentives and institutional arrangements would lead to better management of the watershed for ecosystem services.

Generally, models do not consider these kinds of interactions; hence the need for a *science of environmental applications.*

Its core characteristics differentiate it from the basic science of Earth and environment:

- *Need driven versus curiosity driven*: Basic science is question driven; in contrast, the new applications science is guided more by societal needs than scientific curiosity. Rather than seeking answers to questions, it focuses on creating the ability to seek courses of action and determine their consequences.
- *Externally constrained*: External circumstances often dictate when and how applications knowledge is needed. The creation of carbon trading markets will not wait until we fully quantify forest carbon content. It will happen on a schedule dictated by policy and economics. Construction and repair of the urban water infrastructure will not wait for an understanding of evolving rainfall patterns. Applications science must be prepared to inform actions subject to these external drivers, not according to academic schedules based on when and how the best knowledge can be obtained.
- *Consequential and recursive*: Actions arising from our knowledge of the Earth often change the Earth, creating the need for new knowledge about what we have changed. For example, the more we knew in the past about locations of fish populations, the more the populations were overfished; our original knowledge about them became rapidly outdated through our own actions. Applications science seeks to understand not just those aspects of the Earth addressed by a particular use scenario, but also the consequences and externalities that result from that use scenario. A recent example is the shift of agricultural land to corn-for ethanol production—an effort to reduce climate change that we now recognize as significantly stressing scarce water resources.
- *Useful even when incomplete*: As the snowpack example illustrates, actions are often needed despite incomplete data or partial knowledge. The difficulty of establishing confidence in the quality of our knowledge is particularly disconcerting given the loss of stationarity associated with climate change. New means of making effective use of partial knowledge must be developed, including robust inference engines and statistical interpretation.

- *Scalable*: Basic science knowledge does not always scale to support applications needs. The example of carbon trading presents an excellent illustration. Basic science tells us how to relate carbon content to measurements of vegetation type and density, but it does not give us the tools that scale this to a global inventory. New knowledge tools must be built to accurately create and update this inventory through cost-effective remote sensing or other means.
- *Robust*: The decision makers who apply applications knowledge typically have limited comprehension of how the knowledge was developed and in what situations it is applicable. To avoid misuse, the knowledge must be characterized in highly robust terms. It must be stable over time and insensitive to individual interpretations, changing context, and special conditions.
- *Data intensive*: Basic science is data intensive in its own right, but data sources that support basic science are often insufficient to support applications. Localized impacts with global extent, such as intrusion of invasive species, are often difficult for centralized projects with small numbers of researchers to ascertain.

New applications-appropriate sources must be identified, and new ways of observing (including the use of communities as data gatherers) must be developed.

Each of these characteristics implies development of *new knowledge types* and *new tools for acquiring that knowledge.* The snowpack example illustrates what this requirement means for a specific application area.

Four elements have recently come together that make deployment of a measurement and information system that can support decisions at a scale of a large river basin feasible:

1. Accurate, sustained satellite estimates of snow-covered area across an entire mountain range;
2. Reliable, low-cost sensors and telemetry systems for snow and soil moisture;
3. Social science data that complement natural and engineered systems data to enable analysis of human decision making;
4. Cyberinfrastructure advances to integrate data and deliver them in near real time.

For snow-dominated drainage basins, the highest-priority scientific challenge is to estimate the spatial distribution and heterogeneity of the s*now water equivalent— i.e.*, the amount of water that would result if the snow were to melt. Because of wind redistribution of snow after it falls, snow on the ground is far more heterogeneous than rainfall, with several meters of differences within a 10 to 100 m distance.

Heterogeneity in snow depth smoothes the daily runoff because of the variability of the duration of meltwater in the snowpack; seasonally, it produces quasi-riparian zones of increased soil moisture well into the summer.

The approach to estimating the snow water equivalent involves several tasks using improved data:

- Extensive validation of the satellite estimates of snow cover and its reflectivity;
- Using results from an energy balance reconstruction of snow cover to improve interpolation from more extensive ground measurements and satellite data;
- Development of innovative ways to characterize heterogeneity;
- Testing the interpolated estimates with a spatially distributed runoff model. The measurements would also help clarify the accuracy in precipitation estimates from regional climate models. This third phase of Earth and environmental science will evolve over the next decade as the scientific community begins to pursue it. Weather science has already built substantial capability in applications science; the larger field of Earth science will need to learn from and extend those efforts. The need for basic science and further discovery will not diminish, but instead will be augmented and extended by this new phase. The questions to address are both practically important and intellectually captivating. Will our hydrologic forecasting skill decline as changes in precipitation diminish the value of statistics obtained from historic patterns? Where will the next big climate change issue arise, and what policy actions taken today could allow us to anticipate it? Equally important is improving how we apply this knowledge in our daily lives. The Internet and mobile telephones, with their global reach, provide new ways to disseminate information rapidly and widely. Information was available to avoid much of the devastation from the Asian tsunami and Hurricane Katrina, but we lacked the tools for rapid decision making and communication of needed actions. Applications science is therefore integrative; it couples understanding of physical phenomena and research into the ways that people and organizations can use better knowledge to make decisions. The public as a whole can also become an important contributor to localized Earth observation, augmenting our limited satellite and sensor networks through devices as simple as mobile phone cameras. The ability to leverage this emerging data-gathering capability will be an important challenge for the new phase of environmental science. The security and prosperity of nearly 7 billion people depend increasingly on our ability to gather and apply information about the world around us. Basic environmental science has established an excellent starting point. We must now develop this into a robust science of environmental applications.

VERTEBRATE-MEDIATED ECOLOGICAL PROCESSES

Ecological interactions have critical importance in the maintenance of biodiversity and ecological functions such as productivity and turnover. Mutualistic interactions are extremely common and include interactions between all major organismal groups, they have been largely neglected in the ecological literature, with greater emphasis placed on competition and predation. Many interactions may be quite unspecific with a great degree of ecological redundancy, such that the loss of a single species member of a mutualism results in little change in the overall outcome of the interaction. The extent of redundancy and the resistance of ecological interactions to anthropogenic disturbances are poorly known, yet of critical importance to forest managers in determining extractive mechanisms and limits. Vertebrate-plant interactions should be of interest to both forest managers and conservation biologists owing to the roles of vertebrates in plant recruitment and in regulating forest structure and composition through pollination, seed dispersal, and seed predation and herbivory.

POLLINATION

Pollination by vertebrates is almost non-existent in northern temperate forests where most species are wind-pollinated. Indeed there is a trend of increasing wind pollination with increasing latitude. In tropical forests, high tree diversity and wide spacing between conspecifics limit the efficiency of wind pollination and tree species in lowland tropical forests are almost all pollinated by animals (including insects). To attract vertebrate pollinators plants need to produce nectar in quantities much greater than that required for insect pollination. The energy costs of nectar production to plants can therefore be considerable. Thus nectar produced by vertebrate-pollinated plants tends to be relatively dilute. Vertebrate-pollinated plants are therefore most abundant in wet tropical climates where water does not limit nectar production, and are rarely found in dry forest or savannah habitats. Among vertebrates, bats, birds and a few non-flying mammals are the only known pollinators; although they pollinate only a minority of plants, they remain crucial for the successful reproduction of many large forest trees and a much greater variety of forest understorey plants.

Well-documented cases of non-flying mammal pollination involve 59 mammal species distributed among 19 families and six orders. The marsupials of Australia (12 species) and primates of Madagascar (9 species) and South America (10 species) are the best-known examples. However, the importance to plants of non-flying mammals as pollinators is debatable, as many of these plants are often served by other vertebrate and insect pollinators. Only in Madagascar do non-flying mammals (lemurs) act as sole pollinators of the plants they visit, and the precipitous decline of some lemur species may cause an associated decline of the plants they pollinate (*e.g.*, the traveller's tree *Ravenala madagascarien-sis* pollinated by the endangered black-and-white ruffed lemur). Selective exclusion experiments have demonstrated that marsupials are at least

as effective as birds in pollinating *Banksia* in Australia and *Protea* spp. in South Africa; indeed, declining small-mammal activity at *Banksia* inflorescences due to habitat fragmentation resulted in a sharp decrease in seed set of *Banksia goodii.*

However, documented cases of reduced seed set due to declines in mammal pollinators are rare. In most cases, evidence for effective pollination by non-flying mammals is largely circumstantial and, while non-flying mammals may feed at flowers and occasionally pollinate them, this service must be balanced with the damage they cause.

Bats pollinate species belonging to several tropical plant families including Bombacaceae *(Pseudobombax),* Mimosaceae *(Parkia),* Passi-floraceae *(Passiflora)* and Caesalpiniaceae *(Bauhinia);* on oceanic islands, such as Samoa, the majority of the dominant canopy tree species may be pollinated by bats. A number of economically important tropical trees rely on bats for pollination, including durian, banana, neem and timber species of *Eucalyptus* and several species of palm. Although it is energetically expensive to produce bat-attracting flowers rich in nectar, plants benefit from extensive pollen transfer as bats forage over large areas. Habitat change, hunting and the introduction of exotic species is causing the decline of bats across the tropics and several species are threatened with extinction. This is of particular concern on oceanic islands, where alternative pollinators for endemic tree species are rare or absent.

In the Neo-tropics hummingbird pollination is widespread among several plant families, while old-world pollinators include a much greater variety of birds, primarily sunbirds but also leafbirds, lorikeets, white-eyes and honey-eaters. However, birds are rarely the exclusive pollinators of plants and their importance relative to insect pollinators is not well resolved. Declines in fruit set due to temporary absence of hummingbirds have been noted, even where other invertebrate pollinators were present, but obligate pollinator dependency by plants on hummingbirds or sun-birds has not been documented. Rather, these birds may be important as biological 'insurance' where temporal fluctuation of invertebrate pollinator populations may be severe.

Loss of vertebrate pollinators resulting from forest conversion or fragmentation is only likely to affect plant seed production if the plant-pollinator interaction is highly specialized. Most plants are pollinated by a suite of mainly general-ist pollinators and are unlikely to suffer a large decline with the loss of one or a few closely related pollinator species. Nevertheless, in tropical floras specialist interactions among animals and plants do exist. On the small isolated Caribbean island of Tobago the absence of hermit hummingbirds resulted in reduced seed production of *Mandevilla hirsuta* (Apocynaceae) compared with the neighbouring island of Trinidad where the birds were present. In contrast, there was no difference across islands in seed production of *Justica secunda* (Acanthaceae) that is pollinated by a more general array of hummingbirds. In fact most hummingbirds appear to be quite plastic in their habitat requirements and regularly use edges and move between primary and secondary habitats to take advantage of a wide

variety of floral resources; there is also evidence that sunbirds, which in the Palaeotropics fill a similar ecological niche to hummingbirds, are more abundant at flowering trees in disturbed secondary forests.

However, predicting the impacts of habitat and landscape modification on plant-pollinator interactions is difficult as both the behaviour and abundance of pollinators may change as a result of changing resource distribution. Pollinators may also depend on resources that are far from the plants they pollinate. In peninsular Malaysia, for example, the fruit bat *Eonycteris spelea* is the exclusive pollinator of durian trees but feeds primarily in coastal mangroves. The bats visit, and pollinate, durian *en route* to the mangroves from their limestone-cave roosts. Destruction of either the caves or the mangroves could affect the bat population and hence the pollination of durian.

Seed Predation

Predation of seeds by animals has been proposed as a mechanism for the maintenance of the high tree species diversity in tropical forests. This theory suggests that density-dependent consumption of seeds by mammalian seed predators prevents domination of the vegetation by species that have competitively superior seeds or greatest seed production. Terborgh (1988) suggested that vertebrate seed predators selectively prey upon the largest tree seeds, and where carnivores are eliminated following perturbations forest composition might shift to smaller-seeded species. There is some evidence to support this prediction from forests in Panama and Mexico. In Panama, high densities of small mammals on Barro Colorado Island due to an absence of large predators is thought to be the cause of recruitment failure among the large canopy tree *Dipteryx panamensis* due to the seed predation pressure exerted by the small mammals.

Some studies show seed predation by vertebrates (most often rodents) to be higher in mature forest compared with early successional forest, while other studies found the opposite. Rodents tend to avoid large areas of open forest or pasture probably due to the lack of protective cover and the scarcity of food resources. However, seed predation intensity under different disturbance regimes varies greatly with the species of seed plant making it difficult to draw generalizations to guide forest restoration programmes.

However, where seed predator densities are high, commercially available low-value grains might be used to satiate the seed predators in order to minimize mortality of the desired species. Use of these methods should be based on a sound knowledge of the factors that limit the population dynamics of the predator species, otherwise the availability of superabundant food resources leads to rapid population growth and subsequent heavy seed mortality in later years.

Seed Dispersal

Seed dispersal has been favoured by evolution because it decreases the probability of seed predation, which is often disproportionately high close to parent trees, and increases the probability that seeds find a suitable establishment site.

Thus seeds have become adapted for dispersal by a variety of vectors, the most common of which are wind and animals, and the role of animals in the dispersal of seed and fruit has received much attention in the biological literature. Seeds carried by animals often have edible appendages (*e.g.*, *Acacia* spp., *Anacardium* spp.) or are enclosed within fleshy fruits that are consumed and the seeds ejected later. In some cases the seeds themselves are harvested but dropped, or stored and later forgotten or abandoned.

In Neo-tropical forests, 50-90 per cent of the canopy trees and nearly all shrubs and subcanopy trees bear fruit adapted for animal dispersal, while a smaller but still substantial proportion of species in Palaeotropical forests are also dispersed by animals (35-48 per cent and 70-80 per cent, respectively). Birds, bats and scatter-hoarding rodents are the major dispersers of tropical tree seeds, while other seed dispersers include primates, fish in Amazonian forest, tortoises, some herbivorous lizards and even a frog.

In temperate coniferous and deciduous forests, seeds may be more often dispersed by wind or by cache-hoarding mammals and birds. However, this dichotomy between temperate and tropical forest dispersal mechanisms has been challenged by Wheelwright (1988), who asserts that interactions between plants and their fruit-eating bird dispersers are as complex and ecologically important in temperate regions as they are in the tropics. Howe and Smallwood (1982) state that more than 60 per cent of temperate trees have animal-dispersed seeds and record a significant negative correlation between annual precipitation and the percentage of wind dispersal. Nevertheless, there are more species of fruit-eating birds in the tropics and they comprise a larger fraction of the avian biomass. Only in the tropics are there bird species that rely exclusively on a diet of fruit (*e.g.*, fruit pigeons *Ptilinopus* spp. in Australia and *Treron* spp. In South-East Asia), and most birds with a predominantly fruit diet are tropical species.

Seed dispersal syndromes are thought to reflect coevolutionary trends between plants and vertebrate (bird and mammal) seed dispersers. Bird-dispersed fruit are small and red, black, blue or purple, are conspicuous by sight rather than smell, and persist on the tree until removed by a disperser. Mammal-dispersed fleshy fruits are large, green or brown, emit odours, and frequently abscise shortly after ripening. However, the existence of clearly defined seed dispersal syndromes has recently been questioned and consumption of a particular type of fruit by an animal does not imply that the fruit is adapted for dispersal by that animal. The emerging view is that most interactions between plants and avian seed dispersers, in both tropical and temperate regions, are generalist, opportunistic and largely inefficient (from the plant's perspective), and there are few examples of tightly coupled coevolved mutu-alistic interactions. One well-documented exception is the commercially important brazilnut *Bertholletia excelsa,* which is entirely dependent on agoutis to gnaw open the seed capsules and release the seeds.

Animal behaviour can be crucial to the success of plant dispersal and recruitment. Animal seed dispersers often place seeds in sites suitable for

germination, and seeds of some species (*e.g.*, oak) will not germinate unless they are buried. Burial further reduces the probability that the seeds will be found by seed predators. Bats may reduce the suitability of fruit to insect seed predator attack, leading to increased survival of seeds dropped at a bat roost.

Animal digging, burrowing and tunnelling (by armadillos, coatis, porcupines, pigs, gophers) can bury seeds or unearth buried seeds. At Mount St Helens, for example, the activity of surviving gophers in bringing soil and propagules to the surface of the sterile ash deposits facilitated plant establishment and the start of forest regeneration (Andersen and Mac-Mahon 1985). Secondary dispersal of wind-dispersed seeds of *Pinus jeffieyi, Pinus ponderosa* and *Pinus contorta* by chipmunks and other rodents in the Sierra Nevada is instrumental in moving seeds up to 69 m away from the parent tree compared with only 12 m by wind dispersal alone. Mockingbirds, doves and land iguanas have been essential in facilitating regeneration of the tree *Bursera graveolans* (Burseraceae) on the Galapagos Islands after the elimination of introduced goats. The *Bursera* seeds fail to germinate directly beneath adult trees, and recovery of the population to levels prior to the introduction of goats is entirely dependent on the native seed dispersers. Vertebrate dispersal agents may further benefit plants by dispersing mycorrhizal fungal spores in addition to seeds, as in the Pacific North-west where squirrels disperse the obligate symbiotic mycorrhizal fungi of conifer seedlings.

Dependence on animals for seed dispersal exposes the plants to the risk of dispersal failure should seed vectors become rare or extinct. The population structure of the tambalocoque tree *Sideroxylon sessiliflorum* (Sapotaceaea) on Mauritius is thought to have been affected by the extinction of the dodo, which dispersed the seeds and whose elimination doomed the tree to extinction as one of the 'living dead'. The likely cause of the dramatic decline of colonization rates of many fleshy fruited species in the remnant rain forests of the Mascarene Archipelago, in which Mauritius is located, is thought to be due to the extinction of over 50 per cent of its land vertebrates in recent decades. Cox *et al.* (1991) describe preliminary observations of pollination and seed dispersal failure for several bat-pollinated and -dispersed plants on the island of Guam where bats have suffered severe declines in recent years. Indeed, Fujita and Tuttle (1991) note that at least 289 plant species (according to current published information) depend to varying degrees on large populations of flying foxes for their propagation, and the fact that flying foxes are increasingly threatened is a cause for broad concern.

Selective logging and fragmentation of forest habitats have a large impact on vertebrate abundance and behaviour, which in turn is likely to affect seed dispersal of many animal-dispersed tree species. Forget and Sabatier (1997) reported that large frugivores avoid recently created gaps, and many bird species do not move into central regions of large gaps.

However the responses of species to fragmentation can be highly variable and the impact on forest tree regeneration is often difficult to predict. Frugivorous

birds may decline sharply after fragmentation leading to decreased seed dispersal, while small mammal populations remain stable or even increase in abundance. However, the behaviour of small mammals may alter as the landscape is transformed into a primary and secondary forest mosaic. Terrestrial mammals readily move between primary and secondary forests and may promote regeneration by dispersing primary forest tree seeds into degraded secondary forest, although seeds can also be transported in the opposite direction and alter the nature of primary forest succession.

Management of animal seed-dispersers may be necessary to accelerate regeneration of degraded areas and to promote the establishment of native plant species. Availability of hollows, snags, perches and nest boxes increases the abundance and diversity of birds and bats, thereby preserving dispersal functions and accelerating forest regeneration. Where vertebrates choose to sit while processing seeds is critical to the reproductive success of plants and appropriate provision of perches and nest boxes can encourage frugivorous birds to process (and defecate) consumed seeds in degraded sites. However, if tightly coupled mutualisms exist between a plant and animal, then specific management strategies may be required to ensure the continued existence of both.

Herbivory

Vertebrate herbivores are instrumental in determining the vegetational composition of forest systems. The role of the African elephant in maintaining the balance between savannah and woodland in Africa is well documented and the impact of grazing and browsing mammals on temperate forests has been reviewed by Gill (1992a,b). The loss of large herbivores from Europe in the Pleistocene is thought to have led to the transformation of short grasslands to less productive forests with concomitant extinctions of many small mammals dependent on the more nutrient-rich vegetation. More recently, the elimination of rabbits by the disease myxomatosis in Britain has resulted in many grassland areas reverting to scrub woodland.

Overgrazing by deer in European and North American woodlands causes a decline in native woodland species, facilitates the spread of invasive weeds, prevents regeneration of woody species and may result in local extirpation of herbaceous plants. Moderate grazing can lead to plant species replacements. In North America, preferential feeding of white-tailed deer on pine *Pinus strobus* results in its replacement by birch *Betula papyrifera,* which has a greater resistance to browsing.

Moderate or low levels of grazing can also result in greater vegetational diversity than either overgrazing or an absence of grazing. Thus, in tropical Mexican forests the defaunation of large mammal herbivores such as tapirs, peccari and deer by hunting and illegal trading led to increased density but decreased diversity of seedlings and saplings. Grazing represents a nutritional drain on plants and the ability to survive sustained grazing pressure may depend on soil quality and efficiency of nutrient capture.

The response of *Colophosper-mum mopane* trees to high levels of elephant herbivory in *C mopane*-dominated woodland in Zambia was related to the availability of soil nutrients; poor soil quality combined with elephant herbivory increased plant species diversity and reduced dominance by *C. mopane.* Periodic large-scale diebacks were also suggested to be a function of soil nutrient depletion from sustained grazing by elephants in these woodlands.

By browsing and debarking seedlings, saplings and trees, large mammalian herbivores can influence forest plant diversity and abundance, which in turn affect the resource and habitat quality and quantity for a range of other plant and animal species. Woodland degradation in Botswana by African elephants resulted in substantial changes in bird species composition, although bird diversity was unchanged, while culling of hippopotamus in Uganda allowed regeneration of plant diversity and consequential increases in buffalo, elephant and waterbuck densities. In tropical wet forests, large mammal densities are considerably lower than in African savannah forests and vertebrate herbivores do not have a major impact on habitat structure or composition.

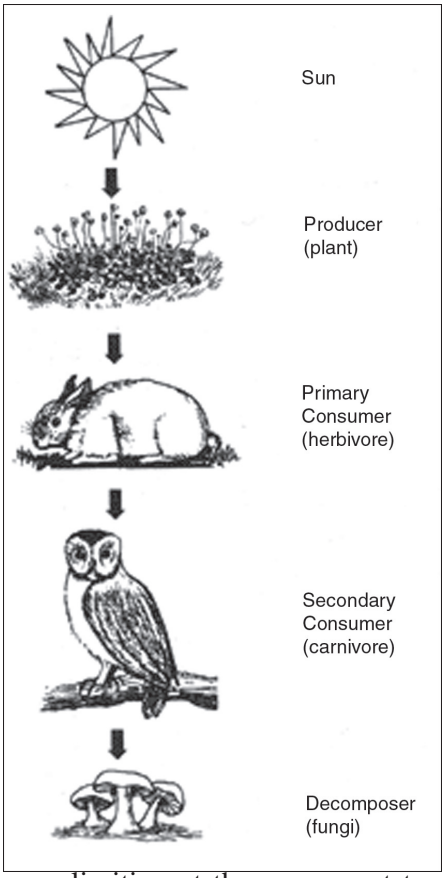
TROPHIC LEVELS

Insect ecology is the branch of entomology that focuses on the interrelationships between insects and their environment. To an ecologist, the concept of "environment" encompasses both the abiotic world (non-living things like climate and geology) as well as the biotic world (all living organisms including plants, animals, microorganisms, *etc.*). All of these components interact within a framework called the biocenose (a natural community).

Communities are groups of organisms (populations) that maintain persistent associations with each other. The members of a typical community include plants, animals, and other organisms that are biologically interdependent through predation, parasitism, and symbiosis. The structure of a biotic community is largely characterized by the trophic (feeding) relationships among its member species. These relationships are often represented simplistically as a food chain. Each link in the food chain represents a trophic level encompassing either producers or consumers.

In most communities, green plants are the dominant producers. They represent the first link in a typical food chain. Plants capture kinetic energy from sunlight and, through the process of photosynthesis, manufacture organic molecules (*e.g.*, simple sugars) from carbon dioxide and water. The captured energy is "stored" in the chemical bonds of these molecules. Some of the stored energy is used by plants for their own survival and growth, some is lost as heat, and some passes on to consumers when the plant is eaten, or to decomposers when the plant dies.

Primary consumers occupy the second link of a food chain. These animals, often called herbivores, survive by feeding exclusively on plants or plant products. The third link includes primary carnivores, secondary consumers that live as predators or parasites of herbivores. Any remaining links in the food chain are occupied by secondary or tertiary carnivores (predators or parasites of other carnivores).



Since energy becomes limiting at the uppermost trophic levels, there are seldom more than four or five links in a terrestrial food chain.

Food Webs

Very few animals have a diet that is restricted to only a single food source, so the concept of a linear food chain is extremely simplistic. In reality, trophic relationships within a community are more like a food web in which dozens of plant species support a wide variety of herbivores which in turn are consumed by numerous predators and parasites.

If one species within a food chain becomes scarce (perhaps due to bad weather or over-exploitation), there will be serious repercussions on all other species in the chain.

But in a complex food web, changes in individual populations are likely to have a smaller impact because they are buffered by the availability of an alternative prey or host.

Insect Herbivores

Animals that feed on plant tissues or plant products are often called herbivores. This term applies not only to insects that injure a plant by chewing leaves or

sucking sap but also to more benign species who only collect pollen, nectar, or plant resins. Entomologists frequently use the noun "phytophagy" and the adjective "phytophagous" when referring to any of these nutritional strategies. Both words are derived from Greek roots: "*phyton*" meaning plant and "*phagein*" the verb to eat or devour.

Phytophagous insects generally use visual or olfactory (odour) cues to locate a host plant. Visual cues may be as simple as the vertical silhouette of a tree or the contrast of white flowers against a dark background of foliage.

Some insects are strongly attracted to certain shapes or colours which they evidently associate with "food". Red spheres, for example, attract adult apple maggots, white pans of water attract aphids, and bright yellow sticky traps attract leafhoppers. Odour cues are plant volatiles such as the saponins in alfalfa, the mustard oils in crucifers, or the terpenes in conifers.

Sometimes these attractants are primary plant compounds such as sugars (*e.g.*, glucose), nucleotides (*e.g.*, adenine), or amino acids (*e.g.*, alanine) that a plant needs for its own survival and growth. But in other cases, the attractants are secondary plant compounds that have no nutritional value to either the plant or the insect.

These substances may be manufactured by the plant as a chemical defence against herbivores but they unwittingly serve as token feeding stimulants to a select group of specially adapted species.

Milkweed plants, for example, produce cardenolides that deter feeding by most phytophagous insects. These chemicals, however, attract monarch butterflies, oleander aphids, milkweed beetles, and a few other species that have the ability to digest or detoxify the compounds.

Insect herbivores often have a cyclical pattern of feeding behaviour. After an initial phase of attraction to the host plant, appropriate tactile (touch) and olfactory (odour) cues trigger the impulse to take a first bite. Additional gustatory (taste) stimuli must be present in order for continued feeding to occur. After a bout of feeding is complete, the insect may leave the host plant to engage in other activites.

Since many plants conduct chemical warfare against insect herbivores by manufacturing repellents or deterrents, it is common for insects to be rather narrow and specialized in their choice of host plant. A monophagous insect restricts itself to a single host species — it is a consummate specialist, adapting its behaviour and physiology to a single nutritional resource.

Some of these insects must rely on intestinal symbionts to supply essential dietary components that are not supplied by their host. Oligophagous insects have a slightly broader host range — often adopting any plant within a close circle of related genera or the members of a single taxonomic family.

These insects are less likely to starve if a preferred host plant is unavailable. A few insects are polyphagous. These species are equipped with "broad-spectrum" detoxification enzymes that can overcome a wide range of plant defences. It can be metabolically "expensive" to produce these enzymes, but on

the other hand, there is no shortage of available food! Some of the more polyphagous insects (like grasshoppers and armyworms) will consume every part of their host plant. But most insect herbivores are more selective: they specialize as leaf chewers, sap suckers, stem borers, root pruners, gall makers, leaf miners, collectors of pollen or nectar, *etc.* Each of these feeding strategies represents a separate ecological niche and all of the species that feed on the same plant in the same way are known as members of a feeding guild. Within a feeding guild, all species compete directly with each other for exactly the same resource. Between members of different guilds, competition is usually less direct and less severe.

As a result, there is strong selective pressure limiting the number of species within each guild. Direct competitors usually are not closely related to each other (phylogenetically) and their association tends to be relatively recent in origin and short-lived in duration compared to more symbiotic (mutualistic) interactions. Natural selection tends to favour adaptations that minimize competition between species within a feeding guild.

Herbivory has had both positive and negative impacts on plants over evolutionary time. Flowering plants (the Angiosperms) have certainly benefited by attracting insect herbivores and exploiting them as pollinators. These plants often provide nectar (or other nutritional "rewards") to their insect accomplices. Bright colours, distinctive odours, geometrical patterns, and in some cases even subterfuge are tactics used by plants to attract specific pollinators and maintain their interest from blossom to blossom (pollinator fidelity). On the other hand, insects are also vectors of plant diseases. Aphids and leafhoppers (Hemiptera: Homoptera) are notorious for spreading plant viruses and mycoplasmas as they feed. Bark beetles (Coleoptera) invade the woody tissues of living trees, inoculating them with fungal pathogens that weaken and eventually kill the tree. Bacteria, protozoa, and nematode pathogens are also carried from plant to plant by insect herbivores. Pathogens may be carried externally on an insect's feet, mouthparts, or ovipositors, or internally in the salivary glands, digestive tract, or reproductive system. Some plant diseases like fire blight (a bacterium) and mummy berry (a fungus) are collected and spread by insect pollinators that are attracted to sticky-sweet exudates produced by the infected plants.

Insect Carnivores

Carnivores eat meat! Some insect carnivores catch and kill other insects (or non-insect arthropods) as food, some parasitize the bodies of other animals, and some feed by sucking blood. Zoophagy is a term for all these feeding strategies. It is derived from the Greek words "*zoion*" meaning animal and "*phagein*" the verb to eat or devour. Predators are zoophagous insects that kill and eat numerous prey individuals in the course of their growth and development. They are generally larger than their prey and must often immobilize or overpower it before feeding.

Some predators are generalists or opportunists: they attack a wide variety of prey species. Others are more narrow in their selection of prey. Agile, fast-

moving predators (like hornets and tiger beetles) can easily overtake and subdue their prey. But other predators (like ambush bugs) blend in with their environment. They wait quietly for prey to approach and then grab it. Doodlebugs, the larval stage of ant lions, dig a shallow pit in loose sand, bury themselves at the bottom, and wait for prey to slide down into their trap. A few predators release an attractive chemical bait that lures prey within range. Predators are often regarded as useful insects when they serve as natural enemies of pest species. An Asian lady beetle, for example, may eat as many as 5000 aphids during its life cycle.

Parasites are usually much smaller than their prey (or host) and may complete their development on the body of a single host individual. Endoparasites live inside the host's body, whereas ectoparasites live in the host's nest or on the surface of its body. A "true" parasite does not kill its host, but it may spread disease pathogens or cause other disability such as skin irritation, intestinal blockage, organ failure, or allergic reactions. Blood feeding (hematophagy) is a common practice among insects that parasitize vertebrate animals. Fleas (order Siphonaptera), sucking lice (order Phthiraptera), bed bugs and conenosed bugs (order Hemiptera), and numerous members of the order Diptera (including mosquitoes, deer flies, black flies, sand flies, and others) seek vertebrate blood meals throughout all or part of their life cycles.

Many zoophagous insects live in or on the body of a single host individual during their larval stage but become free-living as adults. These insects do not fit the classical definition of a "parasite" because they feed on the internal organs and tissues of the host individual and eventually kill it.

Entomologists call these insects parasitoids to distinguish them from "true" parasites such as fleas and mosquitoes. Most parasitoid species are members of the orders Diptera and Hymenoptera. Adult females use chemical cues to locate their hosts for oviposition. After hatching, young parasitoid larvae feed on non-vital tissues within the host's body (*e.g.*, fat body). As the larvae grow, their nutritional demands increase until they eventually consume their hosts from the inside.

The term "parasite" also encompasses several groups of zoophagous insects that have been given special names because they have distinctive ecological characteristics:

- Hyperparasites are parasites (or parasitoids) of another parasitoid species.
- Autoparasites are species in which the females feed on males to obtain a nutritional advantage.
- Brood parasites are insects that live in the nests of social insects and feed on the juveniles.
- Social parasites are insects that steal food or other resources from the nests of social insects.

Insect Decomposers

The dead bodies of plants and animals are a rich source of organic matter that provides nutrition for many insects called saprophages (from the Greek

words "*sapros*" meaning rotten and "*phagein*" the verb to eat or devour. Insects adapted to this lifestyle are an essential part of the biosphere because they help recycle dead organic matter.

Within the ranks of saprophagous insects, entomologists recognize several major groups:

- Those that feed on dead or dying plant tissues
- Those that feed on dead animals (carrion), and
- Those that feed on the excrement (feces) of other animals.

The dead plant feeders include a wide variety of soil- and wood-dwelling species that shred leaves or tunnel in woody tissues. They accelerate decay by increasing the surface area exposed to weathering and the action of other decomposers. They are largely responsible for creating a layer of humus that often covers the soil. This layer serves as an incubator for the fungi, bacteria, and other microorganisms that release carbon, nitrogen, and mineral elements for uptake by living plants.

Carrion feeders include numerous beetles, fly larvae (maggots), wasps, ants, mites, and others. Each species colonizes the dead body for only a limited period of time but, as a group, they rapidly consume and/or bury the decaying flesh. Blow flies, usually the first to arrive on a carcass, are also the first to complete development and depart. Other species follow over time in a relatively predictable sequence as the body decomposes. This change in the species composition of saprophages is called faunal succession. It provides a reliable way to determine the time elapsed since death and has become a useful tool for police, medical examiners, and other practicioners of forensic entomology.

Many species of manure flies and dung beetles are attracted to the odour of animal excrement. Adults lay their eggs on fresh feces and larvae feed on the organic matter in these waste products. Many dung-feeders exhibit distinct preferences for particular types of manure: the species associated with horse manure, for example, may be quite different from those found on the same farm in cattle manure.

One group of dung beetles, called tumblebugs, form the excrement into a small ball and roll it into a hole that was previously dug in the soil. They lay an egg on the ball of dung and cover it with soil to serve as a nursery for their larvae. In addition to their role as decomposers, some saprophagic insects also serve as pollinators for plants like skunk cabbage and wild ginger.

These plants produce drab coloured, foul smelling flowers that attract the attention of blow flies or carrion beetles. The insects crawl around in the flowers looking for food and unwittingly pick up pollen. Finding nothing to eat, the insects leave and continue to forage for food, perhaps visiting another blossom and transferring pollen.

8

Environmental Pollution

Environmental pollution is any discharge of material or energy into water, land, or air that causes or may cause acute (short-term) or chronic (long-term) detriment to the Earth's ecological balance or that lowers the quality of life. Pollutants may cause primary damage, with direct identifiable impact on the environment, or secondary damage in the form of minor perturbations in the delicate balance of the biological food web that are detectable only over long time periods.

Until relatively recently in humanity's history, where pollution has existed, it has been primarily a local problem. The industrialization of society, the introduction of motorized vehicles, and the explosion of the human population, however, have caused an exponential growth in the production of goods and services. Coupled with this growth has been a tremendous increase in waste by-products.

The indiscriminate discharge of untreated industrial and domestic wastes into waterways, the spewing of thousands of tons of particulates and airborne gases into the atmosphere, the "throwaway" attitude towards solid wastes, and the use of newly developed chemicals without considering potential consequences have resulted in major environmental disasters, including the formation of smog in the Los Angeles area since the late 1940s and the pollution of large areas of the Mediterranean Sea. Technology has begun to solve some pollution problems, and public awareness of the extent of pollution will eventually force governments to undertake more effective environmental planning and adopt more effective antipollution measures. Pollution is the introduction by man into the environ-ment of contaminants that cause harm or

discomfort to humans or other living organisms, or damage the environment Pollution can be in the form of chemical substances, or energy such as noise, heat, or light. Pollutants can be naturally occurring substances or energies, but are considered contaminants when in excess of natural levels. Pollution is often categorized into point source and no point source pollution. An important aspect of the notion of pollution is that ecological change must actually be demonstrated. If some potentially polluting substance is present at a concentration or intensity that is less than the threshold required to cause a demonstrable ecological change, then the situation would be referred to as contamination, rather than pollution.

Some other elements can be present in very large concentrations, aluminum and iron, which are important constituents of rock and soil. Aluminum constitutes 8-10 per cent of the earth's crust and iron 3-4 per cent. However, almost all of the aluminum and iron present in minerals are insoluble in water and are therefore not readily assimilated by biotic community and cannot cause toxicity. In acidic environments, however, ionic forms of aluminum are solubilized, and these can cause toxicity in concentrations of less than one part per million. Therefore, the bio-availability of a chemical is an important determinant of whether its presence in some concentration will cause pollution.

Most instances of pollution result from the activities of humans can be caused by:

- The emission of sulfur dioxide and metals from a smelter, causing toxicity to vegetation and acidifying surface waters and soil,
- The emission of waste heat from an electricity generating station into a river or lake, causing community change through thermal stress, or
- The discharge of nutrient-containing sewage wastes into a water body, causing eutrophication.

Most instances of anthropogenic pollution have natural analogues, that is, cases where pollution is not the result of human activities. Pollution can be caused by the emission of sulfur dioxide from volcanoes, by the presence of toxic elements in certain types of soil, by thermal springs or vents, and by other natural phenomena. In many cases, natural pollution can cause an intensity of ecological damage that is as severe as anything caused by anthropogenic pollution.

An interesting case of natural air pollution is the Smoking Hills, located in a remote and pristine wilderness, virtually uninfluenced by humans. However, at a number of places along the 18.63 miles (30 km) of seacoast, bituminous shales in sea cliffs have spontaneously ignited, causing a fumigation of the tundra with sulfur dioxide and other pollutants. The largest concentrations of sulfur dioxide (more than two parts per million) occur closest to the combustions. Further away from the sea cliffs the concentrations of sulfur dioxide decrease rapidly. The most-important chemical effects of the air pollution are acidification of soil and fresh water, which in turn causes a solubilization of toxic metals. Surface soils and pond waters commonly have pHs less than 3, compared with about Ph 7 at non-fumigated places. The only reports of similarly acidic water

are for volcanic lakes in Japan, in which natural pHs as acidic as 1 occur, and pH less than 2 in waters affected by drainage from coal mines. At the Smoking Hills, toxicity by sulfur dioxide, acidity, and water-soluble metals has caused great damage to ecological communities. The most- intensively fumigated terrestrial sites have no vegetation, but further away a few pollution-tolerant species are present. About one kilometer away the toxic stresses are low enough that reference tundra is present. There are a few pollution-tolerant algae in the acidic ponds, with a depauperate community of six species occurring in the most-acidic pond in the area. Other cases of natural pollution concern places where certain elements are present in toxic amounts. Surface mineralizations can have toxic metals present in large concentrations, copper at 10 per cent in peat at a copper-rich spring in New Brunswick, or surface soil with 3 per cent lead plus zinc on Baffin Island. Soils influenced by nickel-rich serpentine minerals have been well-studied by ecologists. The stress-adapted plants of serpentine habitats form distinct communities, and some plants can have nickel concentrations larger than 10 per cent in their tissues. Similarly, natural soils with large concentrations of selenium support plants that can hyperaccumulate this element to concentrations greater than 1 per cent. These plants are poisonous to livestock, causing a toxic syndrome known as *blind staggers*.

There are many well-known cases where pollution is caused by anthropogenic emissions of chemicals. Some examples include:

- Emissions of sulfur dioxide and metals from smelters can cause damage to surrounding terrestrial and aquatic ecosystems. The sulfur dioxide and metals are directly toxic. In addition, the deposition of sulfur dioxide can cause an extreme acidification of soil and water, which causes metals to be more bio-available, resulting in important, secondary toxicity. Because smelters are point sources of emission, the spatial pattern of chemical pollution and ecological damage displays an exponentially decreasing intensity with increasing distance from the source.
- The use of pesticides in agriculture, forestry, and around homes can result in a non-target exposure of birds and other wildlife to these chemicals. If the non-target biota is vulnerable to the pesticide, then ecological damage will result. During the 1960s urban elm trees in the eastern United States were sprayed with large quantities of the insecticide DDT, in order to kill beetles that were responsible for the transmission of Dutch elm disease, an important pathogen. Because of the very large spray rates, many birds were killed, leading to reduced populations in some areas. Birds and other non-target biota have also been killed by modern insecticide-spray programmes in agriculture and in forestry.
- The deposition of acidifying substances from the atmosphere, mostly as acidic precipitation and the dry deposition of sulfur dioxide can cause an acidification of surface waters. The acidity solubilizes metals, most

notably aluminum, making them bio-available. The acidity in combination with the metals causes toxicity to the biota, resulting in large changes in ecological communities and processes. Fish are highly intolerant of acidic waters.

- Oil spills from tankers and pipelines can cause great ecological damage. When oil spilled at sea washes up onto coastlines, it destroys seaweeds, invertebrates, and fish, and their communities are changed for many years. Seabirds are very intolerant of oil and can die of hypothermia if even a small area of their feathers is coated by petroleum.
- Most of the lead shot fired by hunters and skeet shooters miss their target and are dispersed into the environment. Waterfowl and other avian wildlife actively ingest lead shot because it is similar in size and hardness to the grit that they ingest to aid in the mechanical abrasion of hard seeds in their gizzard.

Humans can also cause pollution by excessively fertilizing natural ecosystems with nutrients. Freshwaters can be made eutrophic by fertilization with phosphorus in the form of phosphate. The most conspicuous symptoms of eutrophication are changes in species composition of the phytoplankton community and, especially, a large increase in algal biomass, known as a *bloom*. In shallow water bodies there may also be a vigourous growth of vascular plants.

These primary responses are usually accompanied by secondary changes at higher trophic levels, including arthropods, fish, and waterfowl, in response to greater food availability and other habitat changes.

However, in the extreme cases of very eutrophic waters, the blooms of algae and other microorganisms can be noxious, producing toxic chemicals and causing periods of oxygen depletion that kill fish and other biota. Extremely eutrophic water bodies are polluted because they often cannot support a fishery, cannot be used for drinking water, and have few recreational opportunities and poor esthetics.

GAS POLLUTION

Any change in the atmosphere's natural mixture of gases has the potential to be significant air pollution. Most gases are invisible, and thus this type of pollution is less obvious. Since it is out-of-sight, it was for many years out of mind. Today, however, gas pollution is a familiar and important problem. Exotic gases can enter the atmosphere from natural as well as human sources. Once in the atmosphere, the gases may cause problems alone or they may form troublesome compounds by combining with particles or other gases.

NATURAL SOURCES

Several important air pollutants have natural sources. One is methane (CH_4). Methane is produced by the bacteria that break down organic matter in the absence of oxygen. This process can occur in swamps, on the sea floor, and inside the bodies of animals. The methane which escapes to the atmosphere

adds to the "Greenhouse Effect". Natural fires produce carbon dioxide (CO_2) which is also a green house gas, and volcanoes produce a great deal of Chlorine gas which may have an effect on the Ozone Layer.

HUMAN SOURCES

In industry, domestic heating and many varieties of transportation, humans produce gases that are released into the atmosphere. In most cases these gases affect the Lower Atmosphere into which they are released, but in some cases they can affect the Upper Atmosphere.

LOWER ATMOSPHERE

The most prominent air polluters are: Sulfur Dioxide (SO_2), Nitrogen Oxides (NOx), Carbon Monoxide (CO), Carbon Dioxide (CO_2) and Chlorofluorocarbons (CFCs).

SULFUR DIOXIDE

Sulfur dioxide (SO_2) is a colourless gas that is produced when the element sulfur is burned. This can happen intentionally during the purification of ores which contain sulfur. In a process known as "smelting", the ore is heated to a high temperature and the sulfur is burned off. Sulfur is burned unintentionally when coal or other fuels containing a large amount of sulfur are used by industries and public utility companies. Whatever its source, once the sulfur enters the atmosphere it combines with water to form sulfuric acid (H_2SO_4) and becomes an important component of acid rain.

NITROGEN OXIDES

Nitrogen oxides are produced when a mixture of nitrogen and oxygen is subjected to high temperatures and high pressures. These conditions occur continuously inside the internal combustion engines that operate automobiles, trucks, trains and small airplanes. These two primary atmospheric gases are drawn into the engines, some of the oxygen is used up as the fuel burns, but the remainder is heated and compressed inside each cylinder as it fires. The resulting nitrogen oxides are responsible for three important air pollution problems.

ECOLOGY MOVEMENTS AND CONFLICTS OVER NATURAL RESOURCES

The recent period in human history contrasts with all the earlier ones in its strikingly high rate of resource utilization. Ever expanding and intensifying industrial and agricultural production has generated increasing demands on the world's total stock and flow of resources. These demands are mostly generated from the industrially advanced countries of the North and the industrial enclaves in the underdeveloped countries of the South. Paradoxically, the increasing dependence of the industrialised societies on natural resources, through the

rapid spread of energy and resource-intensive production technologies, has been accompanied by the spread of the myth that increased dependence on modern technologies implies a decreased dependence on nature and natural resources This myth is supported by the introduction of a long and indirect chain of resource utilisation which leaves invisible the real material resource demands of the industrial processes.

Through this combination of resource intensity at the material level and resource indifference at the conceptual and political levels, conflicts over natural resources generated by the new pattern of resource utilisation are generally shrouded and overlooked. These conflicts become visible when resource and energy-intensive industrial technologies are challenged by communities whose survival depends on the conservation of resources threatened by destruction and overexploitation, or when the devastatingly destructive potential of some industrial technologies is demonstrated as in the Bhopal disaster.

For centuries, vital natural resources like land, water and forests had been controlled and used collectively by village communities thus ensuring a sustainable use of these renewable resources. The first radical change in resource control and the emergence of major conflicts over natural resources induced by non-local factors was associated with colonial domination of this part of the world. Colonial domination systematically transformed the common vital resources into commodities for generating profits and growth of revenues. The first industrial revolution was to a large extent supported by this transformation of commons into commodities which permitted European industries access to the resources of South Asia. With the collapse of the international colonial structure and the establishment of sovereign countries in the region, this international conflict over natural resources was expected to be reduced and replaced by resource policies guided by comprehensive national interests.

However, resource use policies continued along the colonial pattern and, in the recent past, a second drastic change in resource use has been initiated to meet the international requirements and the demands of the elites in the Third World, leading to yet another acute conflict among the diverse interests. The most seriously threatened interest, in this conflict, appears to be that of the politically weak and socially disorganised group whose resource requirements are minimal and whose survival is primarily dependent directly on the products of nature outside the market system. Recent changes in resource utilisation have almost wholly by-passed the survival needs of these groups. These changes are primarily guided by the requirements of the countries of the North and of the elites of the South.

This book analyses environmental conflicts in contemporary human society. In general it relates to societies all over the world, but in particular it addresses the most intense and emerging social contradictions in India related to conflicts over natural resources. Science and technology are central to these conflicts because while scientific knowledge has been used by contemporary societies to considerably enlarge man's access to natural resources, it has also allowed the

utilisation natural resources at extremely high rates. The contemporary period is characterised by the emergence of ecology movements in all parts of the world which are attempting to redesign the pattern and extent of natural resource utilisation to ensure social equality and ecological sustainability. Ecology movements emerging from conflicts over natural resources and the people's right to survival are spreading in regions like the Indian subcontinent where most natural resources are already being utilised to fulfil the basic survival needs of a large majority of people.

The introduction of resource and energy-intensive production technologies under such conditions leads to economic growth for a small minority while, at the same time, undermines the material basis for the survival of the large majority.

In this way, ecology movements have questioned the validity of the dominant concepts and indicators of economic development. The ideology of economic development, which remained almost monolithic in the post World War II period, is thus faced with a major foundational challenge.

In this chapter an attempt has been made to provide a systematic conceptual framework for analysing the processes and structures of modern economic development from an ecological -perspective. It attempts to analyse the relationship between economic development and conflicts over natural resources to trace the roots of ecological movements.

Further, in the light of the ecological perspective, it examines the fundamental assumptions and categories of modern development economics that are used to determine the objectives of economic development as well as the criteria for the choice of technologies that are used to achieve these objectives.

ECONOMIC DEVELOPMENT AND ENVIRONMENTAL CONFLICTS IN INDIA

A characteristic of indian civilization has been its sensitivity to natural ecosystems. vital renewable natural resources like vegetation, soil and water were managed and utilised according to well defined social norms that respected the known ecological processes. The indigenous modes of natural resources utilisation were sensitive to the limits to which these resources could be used It is said that the codes of visiting important pilgrim centres Badrinath in the sensitive Himalayan ecosystem, included a maximum stay of one night so that the temple area would not put excess pressure on the local natural resources base. In the precolonial indigenous economic processes, the levels of utilisation of natural resources were not significant enough to result in drastic environmental problems. There were useful social norms for environmentally safe resource utilisation and people protested against the destructive use of resources even by kings. A major change in the utilisation of natural resources of India was introduced by the British who linked the resources of this country with the direct and large nonlocal demands of Western Europe. Natural resource utilisation by the East India Company, and later by the colonial rulers, replaced the indigenous organizations for the utilisation of natural resources, like water, forest and minerals, that were mainly managed as

commons. With the establishment of British colonial rule in India, the ever increasing resource demands of-the industrial revolution in England were largely met from colonies like India. Forced cultivation of indigo in Bengal and Bihar, cultivation of cotton in Gujarat and the Deccan led to large-scale commitment of land for the supply of raw materials for the British textile industry, the flagbearer of the industrial revolution. Forests in the sensitive mountain ecosystems like the Western Ghats or the Himalayas were felled to build battleships, or to meet the requirements of the expanding railway network. Forests of the Bengal-Bihar-Orissa region were used for running wood fuel locomotives in the early stages of railway expansion.

The latter stages of colonial resource utilisation and control included the monopolization. of water rights as in the Sambhar Lake of Rajasthan or the Damoda' Canal in Bengal. Colonial intervention in natural resource management in India led to conflicts over vital renewable natural resources like water or forests and induced new forms of poverty and deprivation. Changes in resource endowments and entitlements introduced by the British came into conflict with the local people's age old rights and practices related to natural resource utilisation As a result local responses were generated through which people tried to regain and retain control over local natural resources.

The indigo Movement in Eastern India, the Deccan Movement for land rights or the forest movement in all forest areas of the country, the Western Ghats, the Central Indian Hills or the Himalayas, were obvious expressions of protest generated by these newly created conflict's. Conflicts generated by the colonial modes of natural resource exploitation could not, however, grow with a local identity. With the progress of the anti-colonial people's movement at the national level, these local protests merged with the national struggle for independence.

With the collapse of colonial rule internationally, and the emergence of sovereign independent countries in the Third World like India, resolution of these conflicts at the local level became a possibility. While political independence vested the control over natural resources with the Indian state, the colonial institutional framework for natural resource management did not change in essence.

Where colonialism collapsed, the slogan of economic development stepped in. There was unfortunately no alternative institutional mechanism other than that of the classical model of development left by the British, with which the newly formed Indian state could respond to the accentuated aspirations of the Indian people for a better life. The same institutions and concepts, nurtured and developed by the colonial rulers were applied to objectives which were exactly opposite to those of the colonial period.

Concepts and categories relating to economic development and natural resource utilisation that had emerged in the specific context of capitalist growth and industrialization in the centres of colonial power were raised to the level of universal assumptions and applicability. The processes which led to deprivation were now entrusted with the responsibility of basic needs satisfaction.

No serious thought was given to the fact that the historical specificity of early industrial development in Western Europe necessitated the permanent occupation of the colonies and the undermining of the local 'natural economy'.' This inexorable logic of resource exploitation, exhaustion and alienation integral to the classical model of economic development based on resource intensive technologies led Gandhi to seek an alternate path of development for India when he wrote:

God forbid that India should ever take to industrialism after the manner of the West. The economic imperialism of a single tiny island kingdom (England) is today keeping the world in chains. If an entire nation of 300 million took to similar economic exploitation, it would strip the world bare like locusts.

While Gandhi's critique was a forewarning against the problems likely to arise by following the classical path of resource-intensive development, at the time of India's independence, there was no clear and comprehensive work plan to realise the Gandhian dream of alternate development that would be resource prudent and would satisfy basic needs. The issues of resource constraints of economic development were, therefore, not highlighted at the theoretical level, partly due to the tremendous pressure of the enhanced developmental aspirations of a newly independent nation, and partly due to the lack of internalization of natural resource parameters within the framework of economics. As the scale of economic development activities escalated from one Five Year Plan to another, the disruption of ecological processes that maintain the productivity of the natural resource base started becoming increasingly apparent.

The classical model of economic development in the case of the newly independent nations resulted in the growth of urban-industrial enclaves where commodity production was concentrated, as well as rapid exhaustion of the internal colonies whose resources supported the enhanced demands of these enclaves. In the absence of ecologically enlightened resource management methods, the pressure of poverty enhanced the pace of economic development activities in the hope of a quick improvement in the standard of living for all, as in the case of Western Europe.

For example, commercial forestry earned more revenue by making increasing amount of timber and pulpwood available in the market but in the process reduced the multipurpose biomass productivity or damaged the hydrology of the forests. People dependent on non-timber biomass outputs of forests like leaves, twigs, fruits, nuts, medicines and oils were unable to sustain themselves, in the face of the commercial exploitation of forests.

The changed hydrological character of the forests affected both the micro-climate and the stream flows, disturbing the hydrological stability and affecting agricultural production.

There are similar examples from all parts of the country, related to almost all massive developmental interventions in India's natural resource system. Ecological degradation and economic deprivation generated by the resource insensitivity and intensity of the classical model of development have resulted

in environmental conflicts, an understanding of which is imperative for the reorientation of our current development priorities and concepts. It is becoming in creasingly clear that these classical concepts and priorities are being used as an alibi to direct 'development' at the national level, while the educated minority elite is the main beneficiary of these 'development' processes.

The ecology movements that have emerged as major social movements in many parts of India are making visible many invisible externalities and pressing for their internalisation in the economic evaluation of the elite-oriented development process.

In the context of a limited resource base and unlimited development aspirations, ecology movements have initiated a new political struggle for safeguarding the interests and survival of the poor, the marginalised, including women, tribals and poor peasants.

ECOLOGY MOVEMENTS AND SURVIVAL

The intensity and range of ecology movements in independent india have continuously widened as predatory exploitation of natural resources to feed the process of development has increased in extent and intensity.

This process has been characterised by the massive expansion of energy and resource-intensive industrial activity and major development projects like large dams, forest exploitation, mining and energy-intensive agriculture. The resource demand of development has led to the narrowing of the natural resource base for the survival of the economically poor and powerless, either by direct transfer of resources away from basic needs or by destruction of the essential ecological process that ensure renewability of the life-supportirig natural resources.

In the light of this background, ecology movements emerged as the people's response to this new threat to their survival and as a demand for the ecological conservation of vital life-support systems. The most significant life-support systems in addition to clean air are the common property resources of water, forests and land on which the majority of the poor people of India depend for survival.

It is the threat to these resources that has been the focus of ecology movements in the last few decades. Among the various ecology movements in India, the Chipko movement (embrace the trees to oppose fellings) is the most well known.

It began as a movement of the hill people in the state of Uttar Pradesh to save the forest resources from exploitation by contractors from outside.' It later evolved into an ecological movement that was aimed at the maintenance of the ecological stability of the major upland watersheds in India. Spontaneous people's response to save vital forest resources was seen in Jharkhand area in Bihar-Orissa border region as well as in Bastar area of Madbya Pradesh where there were attempts to convert the mixed natural forests into plantations of commercial tree species, to the complete detriment of the tribal people. In the southern part of India the Appiko movement, which was inspired by the success of the Chipko movement in the Himalayas, is actively involved in stopping illegal over-felling of forests and in replanting forest lands with multipurpose

broad leaved tree species. In Himachal Pradesh the Chipko activists have intensified their opposition to the expansion of monoculture plantation of the commercial Chir Pine (Pinus roxburghii). In the Aravalli Hills of Rajasthan there has been a massive programme of tree planting to give employment to those hands which were hitherto engaged in felling of trees.

The exploitation of mineral resources, in particular the opencast mining in the sensitive watersheds of the Himalayas, the Western Ghats and Central India have also resulted in a great deal of environmental damage. As a consequence, environmental movements have come up in these regions to oppose the reckless mining operations.

Most successful among them is the movement against limestone quarrying in the Doon Valley. Here, volunteers of the Chipko movement have led thousands of villagers, in peaceful resistance, to oppose the reckless functioning of limestone quarries that is seen by the people as a direct threat to their economic and physical survival.'

While the Doon Valley instance has a long history of popular opposition to the quarrying of limestone and a Supreme Court order has restricted the area of quarrying to a minimum, examples of such success' of ecology movements are rare People's ecology movements against mineral exploitation in the neighbouring areas of Almora and Pithoragarh still seem to be ignored, probably due to the relative isolation of these interior areas.

Beyond the Himalayas, the ecology movement in the Gandhamardan Hills in Orissa against the ecological havoc of bauxite mining has gained momentum and it draws inspiration from the Chipko movement.

The mining project of the Bharat Aluminium Company (BALCO) in the Gandhamardan Hills is being opposed by local youth organisations and tribal people whose survival is directly under threat. The peaceful demonstrators have claimed that the project could be only continued 'over our dead bodies. The situation is more or less the same in large parts of Orissa-Madhya Pradesh region where rich mineral and coal deposits are being opened up for exploitation and thousands of people in these interior areas are being pushed to deprivation and destitution.

This is also true of the coal mining areas around the energy capital of the country in Singrauli. In these interior areas of Central India, movements against both mining and forestry are becoming increasingly volatile and people's resistance is growing.

Large river valley projects, which are coming up in India at a very rapid pace, is another group of development projects against which people have organised ecology movements. The large-scale submersion of forest and agricultural lands, a prerequisite for the large river valley projects, always takes a heavy toll of dense forests and the best food growing lands. These have usually been the material basis for the survival of a large number of people in India, specially tribal people.

The Silent Valley project in Kerala was opposed by the ecology movement on the ground of its being a threat, not to the survival of the people directly, but

to the gene pool of the Tropical Rainforests threatened by submersion. The ecological movement against the Tehri high dam in the UP Himalaya exposes the possible threat to people living both above and below the dam site through large-scale destabilization of land by seepage and strong seismic movements that could be induced by impoundment.

The Tehri Dam Opposition Committee has appealed to the Supreme Court against the proposed dam by identifying it as a threat to the survival of all people living near the river Ganga up to West Bengal. Most notable among the people's movements against dams on the issue of direct threat to survival from submersion are Bedthi lcchampalli, Bhopalpatnam, Narmada Sagar, Koel-Karo, Bodhghat, *etc.*

In the context of the already overutilised land resources, the proper rehabilitation on a land-to-land basis of millions of people displaced through the construction of dams seems impossible. The cash compensation given instead is inadequate in all respects for providing an alternate livelihood for the majority of the displaced. Destitution is thus the first and foremost precondition for initiating large dam projects

While the process of construction of dams itself invites opposition from ecology movements, the functioning of water projects dependent on the constructed dams results in further ecological disasters and movements. People's movements against widespread water-logging, salinisation and the resulting desertification in the command areas of many dams have been registered. Among them are instances of protests against the Tawa, Kosi, Gandak, Tungabhadra, Malaprabha, Ghatprabha projects and the canal irrigated areas of Punjab and Haryana. While excess water led to ecological destruction in these cases, improper and unsustainable use of water in the arid and semi-arid regions generated ecology movements in a different way. The anti-drought and desertification movement is gaining momentum in the dry areas of Maharashtra, Karnataka, Rajasthan, Orissa, *etc.* Ecological water use for survival is being advocated by water based movements like Pani Chetana, Pani Panchayat, and Mukti Sangharsh. Another major movement originating from the ecological destruction of resources by growth based development is spreading all along the 7,000 km long coastline of India. It is the movement of the small fishing communities against the ecological destruction caused by mechanised fishing whose instant profit motive is destroying the coastal ecology and its long-term biological productivity in a big way.

No amount of threat to survival in India from environmental hazards can be complete without a reference to the Bhopal tragedy on 2 December 1984, in which several thousand people died and several lakhs faced serious health hazards following the leakage of poisonous Methyl Iso Cyanate from a pesticide plant of Union Carbide (India) Limited.

People's movements for clean air and water are growing in ail parts of the country just as ecologically irresponsible industrialization is moving deeper into the hinterland in search of new resources.

WATER POLLUTION

Out of India's 3,119 towns and cities, just 209 have partial treatment facilities, and only 8 have full wastewater treatment facilities (WHO 1992). 114 cities dump untreated sewage and partially cremated bodies directly into the Ganges River. Downstream, the untreated water is used for drinking, bathing, and washing. This situation is typical of many rivers in India as well as other developing countries. Open defecation is widespread even in urban areas of India. Water resources have not been linked to either domestic or international violent conflict as was previously anticipated by some observers. Possible exceptions include some communal violence related to distribution of water from the Kaveri River and political tensions surrounding actual and potential population displacements by dam projects, particularly on the Narmada River.

GANGA

To know why 1,000 Indian children die of diarrhoeal sickness every day, take a wary stroll along the Ganges in Varanasi. As it enters the city, Hinduism's sacred river contains 60,000 faecal coliform bacteria per 100 millilitres, 120 times more than is considered safe for bathing. Four miles downstream, with inputs from 24 gushing sewers and 60,000 pilgrim-bathers, the concentration is 3,000 times over the safety limit. In places, the Ganges becomes black and septic. Corpses, of semi-cremated adults or enshrouded babies, drift slowly by.

More than 400 million people live along the Ganges River. An estimated 2,000,000 persons ritually bathe daily in the river, which is considered holy by Indians. In the Hindu religion it is said to flow from the lotus feet of Vishnu (for Vaisnava devotees) or the hair of Shiva (for Saivites). The spiritual and religious significance could be compared to what the Nile river meant to the ancient Egyptians. While the Ganges may be considered holy, there are some problems associated with the ecology. It is filled with chemical wastes, sewage and even the remains of human and animal corpses which carry major health risks by either direct bathing in the water (*e.g.*: Bilharziasis infection), or by drinking (the Fecal-oral route).

YAMUNA

NewsWeek describes Delhi's sacred Yamuna River as "a putrid ribbon of black sludge" where fecal bacteria is 10,000 over safety limits despite a 15-year programme to address the problem. Cholera epidemics are not unknown.

AIR POLLUTION

Indian cities are polluted by smokes from vehicles and industries. Road dust due to vehicles also contributing up to 33% of air pollution In cities like Bangalore, around 50% of children suffer from asthma. India has emission standard of Bharat Stage II (Euro II) for vehicles since 2005.

One of the biggest causes of air pollution in India is from the transport system. Hundreds of millions of old diesel engines continuously burning away diesel

which has anything up to 200 times the amount of sulphur out European diesel has. Of course the biggest problems are in the big cities where there are huge concentrations of these vehicles. On the positive side, the government appears to have noticed this massive problem and the associated health risks for it's people and is slowly but surely taking steps. The first of which was in 2001 when it ruled that it's entire public transport system, excluding the trains, be converted from diesel to compressed gas (CPG). Electric rickshaws are being designed and will be subsidised by the government but the supposed ban on the cycle rikshaws in Delhi will require a huge increase on the reliance of other methods of transport, mainly those with engines. In this case it seems, one step forward two steps!

It also appeared that the excessive pollution was having an adverse effect on the Taj Mahal. After a court ruling all transport in the area was shut down shortly followed by the closure of all industrial factories in the area. The air pollution in the big cities is rising to such an extent that it is now 2.3 higher than the amount recommended by WHO (world health organisation).

Environmental pollution is a global problem and the whole humanity is worried as to how to control it. Each nation is trying its best to reduce the polluting factors to save the human life. With the new advanced research analyses, through satellites, man has been able to find the causes of possible depletion of the Ozone layer and its consequent effects. They talk about pollution through excessive refrigeration, fuel burning, industrial pollution and other such factors, but nobody has been able to imagine about the pollution being caused by the dead bodies when consigned for cremation in non-scientific manner. We cry about the problem but no problem can be solved unless you provide an alternate or solution to it. The four areas identified for pollution namely Air, Water, Earth and Space, have been well researched and discovered.

The visible areas to the human eye - Earth and Water, catch easily the attention but the other two areas of Air and Space, which are invisible to the common eyesight, are under constant study, vigil and remedial efforts. One of a very neglected or un- noticed area is pollution created at the Cremation Grounds though many countries in the World today, practise this system of cremation of human bodies besides the Hindus. The practice of cremation of human bodies after death, travelled from India to Egypt, from Egypt to Italy and then from Italy to Europe. With the passage of time and the influence of Christianity and then later, the Islam, this practice got partially converted to burying the dead bodies.

In the year 1873, an exhibition in Vienna displayed a Cremation Furnace that was being used in Italy. Seeing this Furnace the Physician of Queen Victoria of England, Sir Henry Thompson wrote a book 'Cremation - the Treatment of the Body after Death' and established a Society named as 'Cremation Society of England'. In the year 1913 'Cremation Association of America' was formed and by 1937 practically all European countries had National Cremation Associations or Societies. The 'International Cremation Federation' has its

headquarters located in London.If the corpses are not consigned to fire, they get degenerated or consumed resulting in the pollution of mother earth, water or atmosphere and through them various germs and worms spread infections and diseases. By consigning the corpse to fire, these pollutions' risks are reduced and if, in that fire some Ghee and Havan Samagri is added, the practice and experiments have established that there is less of environmental pollution and emission of foul smell because of their disinfecting properties. By adding ghee to the fire, the rise in temperature of the flames results in total destruction of those germs and worms. As per tests undertaken jointly by CANA (Cremation Association of America) and EPA (Environmental Protection Agency on Human and Animal Crematories) in June 1999, when the dead body is confined to fire for cremation, the results showed that the emissions of nearly all the tested pollutants are increased when the operating temperature was raised.

This indicates that there is no justification or benefit for the high operating temperatures as well. In India 78% of the population consign the dead bodies to fire for cremation as a ritual. Traditionally they have been using butter ghee and a few herbs while the body is confined to fire. These are required since the wood-fire temperature does not go beyond 300 C or 600 F but when the butter ghee is added the temperature obtained is upto 700 C or 1400 F, which has been proved now scientifically to be optimum temperature required for cremation of a human body.

Just as the low temperature creates pollution, higher temperature is also found to create pollution with emissions dangerously harmful for the environment. Paryavaran Sanrakshan Nyas a voluntary Social Organisation fighting against environmental pollution. This is the first non-government society with registered office at Chandigarh (India) to fight against pollution caused at Cremation Grounds. Paryavaran Sanrakshan Nyas chose to undertake this task which had escaped the attention of the people in the urbanised cities. In rural areas in villages even today, they use lot of ghee, herbs and cow dung (which is a strong anti-pollution agent when burnt) to arrest this pollution. Besides, the Cremation Grounds in the villages are placed at far-isolated areas, away from the populated localities.

In cities, the situation is different. The Cremation Grounds are mostly located in and around the habitated areas affecting seriously the living population. Aware of all these factors and the problem, four women- M/s. Savita Sethi, Sudesh Gupta, Prem Lata Duggal and Usha Ghai of Chandigarh thought of the issue and decided to fight out this un-noticed pollution being caused in the 'City Beautiful' and create awareness amongst the residents. To carry out the mission they decided to form a Trust and elicit support and co-operation from elite and awakened members of the society. Subsequently a Trust under the name of Paryavaran Sanrakshan Nyas was got registered at Chandigarh with nine Trustees of the Nyas. The Trust believed that besides contributing to this noble social cause of pollution control, a respectful and appropriate adieu could be also given, to the departed soul of those unprivileged people who are not able to

bear this bare minimum for the last rites of their beloved ones. The Trustees decided that on every cremation the Trust shall contribute one kg. of pure Ghee and five kgs. of Havan Samagri (a mixture of organic herbs having ingredients which have anti-pollutant, disinfectant, aromatic, nourishing and nutritive qualities.)

Observing such usefulness of Havan Samagri in cremations, the 'PARYAVARAN SANRAKSHAN NYAS CHANDIGARH' – a registered Trust constituted by prominent citizens of this City, had resolved for voluntary contribution of 5 kgs. of Havan Samagri mixed in 1 kg. of Desi Ghee on every cremation of any caste, creed or faith at the Chandigarh Crematorium and thus save the City from such threatened possible pollution.

Finding the financial implications involved, the difficulties and the limitations foreseen, and the responsibility ahead, the Project was launched on 1.1.2005, on experimental basis, initially, on one-day-a-week programme, (on Saturdays only), from the finances made available by voluntary contributions of the Trustees only. The work has been successfully carried out continuously for two years now, (on this one day- a-week arrangement) with the contributions of the Trustees, co-operation of some volunteers and the help of the public.

The Trust has been able to project thus, the necessity and the vital importance of this subject which unfortunately had escaped the attention, of the State government or©and the society at large as well, so far. Municipal Corporation of Chandigarh, realising, recognizing and appreciating the services done by the Trust, -its usefulness and requirement, has constructed at its own cost and expense a shelter accommodation at the Cremation Grounds Sector 25, Chandigarh for the convenient running and management of this Project. The Trust is very hopeful and confident that the enlightened and much awakened people of Chandigarh shall help the Trust in promoting this Project while paying a respectful adieu to the departed human souls, through this act, in accordance with the Vedic directions and practised rituals, and, save this City Beautiful also, from this environmental pollution for better health and safety of our coming generations.

The Trust had started this Project on the New Year Day of 2005, on One-Day-a-Week programme (Saturdays only) basis but plans to increase it gradually with your co-operation and help to a daily practice.

It is just an effort to bring this awakening in the society and sincerely believe that the awakened members of the society and the enlightened residents of the City, shall come forward to support and work for this project. In view of its global acceptance, the civic-minded people shall come forward to contribute liberally their share to this noble project undertaken by Paryavaran Sanrakshan Nyas.

Everyone is welcome to join us in this fight against this extremely harmful pollution, both financially and physically by giving some time, for the benefit of our ownselves, for our future generations, the humanity and all the living beings around.

NOISE POLLUTION

Noise pollution (or environmental noise) is displeasing human-, animal-or machine-created sound that disrupts the activity or balance of human or animal life. A common form of noise pollution is from transportation, principally motor vehicles. The word *noise* comes from the Latin word *nausea* meaning seasickness. The source of most noise worldwide is transportation systems, motor vehicle noise, but also including aircraft noise and rail noise. Poor urban planning may give rise to noise pollution, since side-by-side industrial and residential buildings can result in noise pollution in the residential area. Other sources are car alarms, office equipment, factory machinery, construction work, groundskeeping equipment, barking dogs, appliances, power tools, lighting hum, audio entertainment systems, loudspeakers and noisy people.

HUMAN HEALTH EFFECTS

Noise health effects are both health and behavioural in nature. The unwanted sound is called noise. This unwanted sound can damage physiological and psychological health. Noise pollution can cause annoyance and aggression, hypertension, high stress levels, tinnitus, hearing loss, sleep disturbances, and other harmful effects. Furthermore, stress and hypertension are the leading causes to health problems, whereas tinnitus can lead to forgetfulness, severe depression and at times panic attacks. Chronic exposure to noise may cause noise-induced hearing loss.

Older males exposed to significant occupational noise demonstrate significantly reduced hearing sensitivity than their non-exposed peers, though differences in hearing sensitivity decrease with time and the two groups are indistinguishable by age 79. A comparison of Maaban tribesmen, who were insignificantly exposed to transportation or industrial noise, to a typical U.S., population showed that chronic exposure to moderately high levels of environmental noise contributes to hearing loss. High noise levels can contribute to cardiovascular effects and exposure to moderately high levels during a single eight hour period causes a statistical rise in blood pressure of five to ten points and an increase in stress and vasoconstriction leading to the increased blood pressure noted above as well as to increased incidence of coronary artery disease.

Noise pollution is also a cause of annoyance. A 2005 study by Spanish researchers found that in urban areas households are willing to pay approximately four Euros per decibel per year for noise reduction.

ENVIRONMENTAL EFFECTS

Noise can have a detrimental effect on animals by causing stress, increasing risk of mortality by changing the delicate balance in predator/prey detection and avoidance, and by interfering with their use of sounds in communication especially in relation to reproduction and in navigation. Acoustic overexposure can lead to temporary or permanent loss of hearing. An impact of noise on animal life is the reduction of usable habitat that noisy areas may cause, which

in the case of endangered species may be part of the path to extinction. One of the best known cases of damage caused by noise pollution is the death of certain species of beached whales, brought on by the loud sound of military sonar.

Noise also makes species communicate louder, which is called Lombard vocal response. Scientists and researchers have conducted experiments that show whales' song length is longer when submarine-detectors are on. If creatures don't "speak" loud enough, their voice will be masked by anthropogenic sounds. These unheard voices might be warnings, finding of prey, or preparations of net-bubbling. When one species begins speaking louder, it will mask other species' voice, causing the whole ecosystem to eventually speak louder. European Robins living in urban environments are more likely to sing at night in places with high levels of noise pollution during the day, suggesting that they sing at night because it is quieter, and their message can propagate through the environment more clearly. Interestingly, the same study showed that daytime noise was a stronger predictor of nocturnal singing than night-time Light pollution, to which the phenomenon is often attributed.

Zebra finches become less faithful to their partners when exposed to traffic noise. This could alter a population's evolutionary trajectory by selecting traits, sapping resources normally devoted to other activities and thus lead to profound genetic and evolutionary consequences.

MITIGATION AND CONTROL OF NOISE

Technology to mitigate or remove noise can be applied as follows:

> *There are a variety of strategies for mitigating roadway noise including: use of noise barriers, limitation of vehicle speeds, alteration of roadway surface texture, limitation of heavy vehicles, use of traffic controls that smooth vehicle flow to reduce braking and acceleration, and tire design. An important factor in applying these strategies is a computer model for roadway noise, that is capable of addressing local topography, meteorology, traffic operations and hypothetical mitigation. Costs of building-in mitigation can be modest, provided these solutions are sought in the planning stage of a roadway project.*

Aircraft noise can be reduced to some extent by design of quieter jet engines, which was pursued vigorously in the 1970s and 1980s. This strategy has brought limited but noticeable reduction of urban sound levels. Reconsideration of operations, such as altering flight paths and time of day runway use, have demonstrated benefits for residential populations near airports. FAA sponsored residential retrofit (insulation) programmes initiated in the 1970s has also enjoyed success in reducing interior residential noise in thousands of residences across the United States.

Exposure of workers to Industrial noise has been addressed since the 1930s. Changes include redesign of industrial equipment, shock mounting assemblies and physical barriers in the workplace. Noise Free America, a national anti-noise pollution organization, regularly lobbies for the enforcement of noise ordinances at all levels of government.

LEGAL STATUS

Governments up until the 1970s viewed noise as a "nuisance" rather than an environmental problem. In the United States there are federal standards for highway and aircraft noise; states and local governments typically have very specific statutes on building codes, urban planning and roadway development. In Canada and the EU there are few national, provincial, or state laws that protect against noise. Noise laws and ordinances vary widely among municipalities and indeed do not even exist in some cities. An ordinance may contain a general prohibition against making noise that is a nuisance, or it may set out specific guidelines for the level of noise allowable at certain times of the day and for certain activities.

Dr. Paul Herman wrote the first comprehensive noise codes in 1975 for Portland, Oregon with funding from the EPA (Environmental Protection Agency) and HUD (Housing and Urban Development). The Portland Noise Code became the basis for most other ordinances for major US and Canadian metropolitan regions. Most city ordinances prohibit sound above a threshold intensity from trespassing over property line at night, typically between 10 p.m. and 6 a.m., and during the day restricts it to a higher sound level; however, enforcement is uneven. Many municipalities do not follow up on complaints. Even where a municipality has an enforcement office, it may only be willing to issue warnings, since taking offenders to court is expensive.

The notable exception to this rule is the City of Portland Oregon which has instituted an aggressive protection for its citizens with fines reaching as high at $5000 per infraction, with the ability to cite a responsible noise violator multiple times in a single day. Many conflicts over noise pollution are handled by negotiation between the emitter and the receiver. Escalation procedures vary by country, and may include action in conjunction with local authorities, in particular the police. Noise pollution often persists because only five to ten percent of people affected by noise will lodge a formal complaint. Many people are not aware of their legal right to quiet and do not know how to register a complaint.

COASTAL LAND USE

The world's coastlines are being subjected to increasing pressure as populations grow, and peoples' needs for transportation, food and recreation expand. Coasts and coastal areas serve a great variety of functions, and each must compete with the others for available space and clean water. In the United States, over 50% of the population lives within 50 miles of a coastline and more of our population is moving to the coast every year. Effective preservation of these valuable lands will have to be based on a knowledge of Coasts and Coastal Processes; an understanding of Coastal Legislation, and an appreciation of the pressures being exerted by a growing Population.

COASTAL PROCESSES

Most changes along the coast are produced by waves. In some places it is possible to see waves accomplish a significant amount of change in only a few hours. The basic process is fairly simple. Most waves are produced by storms out at sea. As the waves approach the coast, they pick up and move coastal materials. The size and orientation of the waves determines what they can do. Small waves tend to move sand and other materials onto a beach, large waves move materials off of a beach, and waves that meet the coast at an angle move materials along the beach.

The amount of change that waves can bring about depends in part on the type of coastline they encounter. South Carolina's coastline is low and flat. This means that it generally receives small to moderate waves, and that changes in sea level can have a dramatic effect. Like most coastlines, South Carolina's should maintain a dynamic equilibrium, or a balance between all of these changes. As waves move sand away from a beach, there should be a matching supply of sand being added to the beach. As rising sea level moves the beach landward, the sand should be able to move with it and there should be room for the new beach to form. As people develop coastlines to create ports, resorts, and marinas, we must make sure that we do not obstruct the natural processes that maintain the beach. If we do not understand how the coastline works, it is likely that we will destroy it.

ORIGIN OF WAVES

When energy from the wind is transferred to the water, waves are produced, and the waves then carry that energy as they travel for hundreds or thousands of miles. This is possible because it is energy that is moving, not water. It is easy to demonstrate this process by floating a ping-pong ball on waves in an area free of wind. The ball will move up and over each wave, and return nearly to its original location. Each wave moves the ball around in a circle, and since the ball is in contact with the water, the water must be moving in the same way. Waves represent energy passing along the surface of the water in much the same way that "waves" of energy can pass through a rug or a rope as one end is shaken up and down.

In the case of waves in deep water, this circular motion is confined largely to the upper layers. Observation indicates that the waves' motion decreases with depth and nearly dies out at a distance below the waves equal to one half of their length. Thus, if waves are found to be about 40 feet long (the distance from one crest to the next), we would know that they are disturbing the water to a depth of about 20 feet. This point is known as the "wave base." Most waves in the ocean, even the very large ones, have a base no more than 40 or 50 feet deep. Since most of the oceans are several thousand feet deep, a 50-foot base is barely disturbing the surface, although such a wave would seem huge to us. This surface motion means that waves can pass fairly easily from one place to the next without a significant loss of energy. Thus the world's oceans become

great collectors of energy that is steadily transported towards the coastlines. When the "waves of energy" reach the coast, they can accomplish a great deal of work by expending this energy over a small area in a short period of time.

SIZE AND ORIENTATION OF WAVES

As waves approach shallow water, they eventually reach the point at which the wave base is equal to the water's depth. As the bottom begins to interfere with the circular motion of the waves, it uses up some of their energy and begins to slow them down. When the leading waves slow down, the following ones push in behind, and the result is that the waves are squeezed together and pushed upward to become larger. As the waves become taller, they become more unstable until they fall forward and "break" on the beach. Each breaking wave can pick up a sizable load of sand, shells, or whatever is available and move it forcefully up the beach.

If closely watched, this beach material will be seen to move in a number of directions:

- *The most obvious motion is up onto the beach and back off again:* As waves pick up sand and move up onto a beach, some of their water soaks into the beach. Since small waves contain less water, they lose a greater percentage of their volume and thus a significant amount of their ability to move sand. Larger waves hold greater volumes of water and thus lose a smaller percentage into the sand. This means that large waves can hold their loads in suspension long enough to carry the sand not only onto the beach, but also back out again. The result is that large waves tend to transport material off the beaches, while smaller waves with less transporting ability tend to build beaches up. This may be seen on many beaches that become smaller during the winter when waves are large, and grow back in summer when waves are smaller.
- *The second motion is along the beach:* The careful observer will note that most waves approach the shore at some angle, not straight-on. This gives the waves the ability to carry material along the beach as well as on and off of it. This means that the sand picked up by a breaking wave will eventually be deposited some distance down the beach. As each wave repeats this process, a sizable amount of sand is moved along the beach face. This is one component of a process known as "longshore transport" that carries many millions of tons of sand and other beach material along coastlines every year.
- *The third motion is the most difficult to see, but easier to experience:* While playing in the surf many people realize that they are being slowly carried down the beach. This second component of longshore transport is a current that can occur in the surf zone. As waves approach the beach at an angle and break, a large amount of water is dumped into a "trough" between the beach face and adjacent rows of sand bars. The breaking waves add water to the trough, but there is no easy way for

the water to escape. Seeking an outlet, the water flows along the beach carrying sand with it until it finds a gap between bars. When a gap is found the water escapes to the ocean in a strong current known as a rip. Though short and narrow, these currents account for what is often called "undertow".

CHANGES IN SEA LEVEL

Variations in sea level can have a dramatic effect on a coastline. Some changes in the ocean's level are small and frequent, some are very slow and gradual, and still others are rare and precipitous. The most obvious changes are the regular rise and fall of the tide. These changes are generally well known, and range from inches in some areas to 40 or 50 feet in others. Along South Carolina's open ocean beaches, the difference between high and low tide is usually between five and seven feet. Coastal residents are well aware of tidal fluctuation and plan for it, but their plans often do not include the slower changes in sea level that occur over decades and centuries. For reasons that are not well understood, the earth's climate has passed through cycles of warming and cooling for eons. When the climate begins to cool, polar ice cover increases and fresh water that would have run into the ocean is tied up as ice.

The result is a drop in sea level. During the last ice age, sea level fell over 300 feet. During warming times, polar ice melts and sea level rises. Over the past 10,000 years, the earth's temperature has been increasing and the sea has been rising. During the last century the rate of warming has increased and the rise in sea level is accelerating. Evidence for this rise can be seen in ancient structures that are being flooded and coastal areas that are being invaded by the sea. There is little that humans can do to slow this rise, and thus our coastal building plans must take it into account. Perhaps the most dangerous rises in sea level are the rapid and often unpredictable "storm surges" that accompany hurricanes and other severe storms. Storms can bring about a dramatic rise in local sea level in two ways. First of all, most large storms are associated with an area of low atmospheric pressure. As atmospheric pressure decreases, the sea bulges up just the way a balloon or a sealed bag would "bulge" as it is taken up a mountain or up in an airplane. Second of all, the effect of this bulge can be made more serious by a strong on-shore wind that "piles" the water up against the coast. The resulting surge of water can produce a "wall of water" ten to twenty feet high that can do a great deal of damage as it moves onto the coast.

TYPES OF COASTLINES

Coasts look very different from one place to the next. Compare the rocky coast of Maine or California with the sandy coasts of the Carolinas or the muddy coast of Louisiana. Some of this variation is due to the material that forms each coast, and some is due to the amount of energy the coastal area receives from waves. Most coasts have some sort of beach where these materials are temporarily deposited. At one end of the spectrum is the very irregular muddy

"beach". In areas like this, the ocean's waves are so small and infrequent that they cannot bring about any significant erosion or transportation of coastal materials. In this very low energy environment, the beach is made up of whatever material is deposited by processes on land. Saltmarshes are common along this type of coast.

Further along the spectrum is the type of coastline that is exposed to waves of moderate energy. In this case, the processes of longshore transport work well most of the time. The very lightest materials (particles of silt and clay) are easily carried away, while the heavier sands and light gravels are spread out along the coast to form smooth, straight, sandy beaches.

At the high energy end of the spectrum, the waves are large and able to cut away and transport almost any material. The result is usually a steep, rocky beach that lies at the foot of a cliff. This type of beach changes frequently as the waves cut away at the base of the cliff and advance the beach landward. Only the heaviest materials are left on the beach, while the rest are soon washed away.

THE BEACH

The word "beach" is familiar to most people, but it has a specific geologic definition. A beach is the area of a coastline that is affected by waves. It extends from the highest point on land that is reached by storm waves, out into the ocean to the point where the waves' bases first contact the bottom. (For convenience, this point is said to be a depth of 30 feet.) Beaches can be composed of any material that can be moved by waves. Some are made of boulders, some are formed from shells and shell fragments, but most beaches have some sort of sand. Sand originates on land from the physical and chemical weathering of rock. Generally it is transported to the coast by streams and is distributed along the beach by the action of waves. Sand is stored temporarily in dunes and sand bars, but over a long period of time, sand is in motion on and off the beach and along the beach. Most of this motion is due to the action of waves, and the amount of work waves can do varies greatly from place to place.

SALTMARSHES

Low energy coasts in protected areas such as estuaries and behind barrier islands collect fine grained sediments (muds and silt) that support plant growth. These areas benefit from their proximity to land and their connection to the ocean. Land areas are a source of nutrients, and the ocean provides stability. The result is that Saltmarshes contain some of the most productive land on earth. An acre of open ocean might be able to produce half a ton of new organic matter each year, a cultivated wheat field might be able to produce about two tons; but saltmarshes can produce nearly ten tons of organic matter per year. This tremendous productivity combined with the stable conditions maintained by the adjacent ocean make saltmarshes ideal nurseries for young sea life. Along the southeastern coast of the U.S., nearly 90% of the commercial fish spend a

portion of their lifetime in saltmarshes. Saltmarshes are also excellent filters that can remove natural and human-produced pollutants from coastal waters. As useful and important as they are, saltmarshes are under pressure in many areas of the country. Marshes lie in the path of coastal resort development, marshes receive much of the pollution sent down rivers, and marshes are often caught between rising sea level and armored coasts. Until recently marshes were seen as useless flat land that should be filled or drained.

COASTAL LEGISLATION

As states such as South Carolina became increasingly aware of the value of their coastal areas, they realized that many of these areas could be lost if they are not protected by strong and realistic legislation. The legislation is needed to protect public lands from damage by private actions, but at the same time the laws needed to be sensitive to the rights of private land owners.

Many people do not believe that South Carolina's legislation has achieved the proper balance between these two needs, but most people believe that action is important even if it is not perfect. South Carolina's action in this area is the South Carolina Coastal Zone Management Act of 1977 and the Beachfront Management Act of 1988. The basic purpose of this legislation is to remove any type of construction from the most active part of the beach. If the beach's natural processes are to work, we must not do anything that will interfere with the natural flow of sand and other beach materials.

These acts attempt to accomplish this with three primary provisions:

- *Base Line*: A base line has been established along the entire coast. This line is the "Primary Dune Line", or a line marking the dunes that are closest to the ocean. This line indicates where the dunes are, or where they would be if they had not been removed. The BFA does not permit any type of construction between the base line and the ocean. Landowners may not take any action to armor the coast or affect the flow of the sand in that area, and no buildings of any sort can be placed there. Existing structures in this area do not have to be removed, but if they are damaged, they cannot be repaired or replaced.
- *Set Back*: Any new construction must be "set back" behind (landward of) the base line. The amount of set back depends on the rate at which the coastline is changing. The set back must be 20 feet, or 40 times the yearly rate of erosion whichever is greater. For example, if the coast in one area is eroding at one foot per year, any new construction must be set back 40 feet behind the base line. If no detectable erosion is occurring, the construction must be at least 20 feet behind the base line. Existing structures within the set back zone cannot be over 5,000 square feet in size, and if they are more than 50% destroyed, they cannot be repaired or replaced.
- *Sea Walls*: Existing sea walls can be repaired or replaced as long as the new structure is tilted backward (away from the ocean) so that the

energy of the waves is not directed downward towards the beach, but upward away from the beach. Without this type of design, a sea wall will destroy the beach in front of it.

POPULATION

The world's total human population is growing, and this growth is seen on most scales from whole counties to cities within countries. Obviously there are exceptions. There are places with stable or shrinking populations, and there are places whose populations are growing more rapidly than others The world's coastlines are one of these exceptions. For one thing, a majority of the world's cities are on coastlines. In the U.S., for example, twenty of our largest twenty five cities are on a salt or fresh water coast. Since the population of most cities is growing disproportionately rapidly, this adds large numbers of people to some coastal areas. With very few exceptions, these cities were established along a coast because of the easy transportation provided by the adjacent water. Non-urban coasts are also growing due to their value for food production and recreation. These various uses of the coast compete with each other for space, clean water, and access to the ocean. Each is going to have to accept limitations on its activities if all are going to survive and prosper.

TRANSPORTATION

Throughout most of human history, water transportation was the only way to move large loads over long distances. Today there are other choices, but water transportation is still the least expensive. Many tons of bulk material such as ore, coal and grain are moved by water each year. Water transportation on a large scale, requires a large amount of construction on and off shore. Channels and port facilities have to be built and maintained, and land-based storage and transportation needs to be readily accessible. Each of these has an effect on the coastal environment. When channels are built and maintained, the dredge spoil (sediment that is removed by dredges) must be dumped somewhere. If dumped in the water, it can cover bottom dwelling organisms and muddy the water.

If the spoil is dumped on land, it can cover valuable land or alter drainage patterns. Port facilities require construction at the water's edge, and unobstructed access to open water. Each of these can serious impair the natural movement of sand and other materials along the coast. In South Carolina, for example, the maintenance of port facilities at Charleston severely limits the natural flow of sand southward along the coast. This limit contributes to the erosion of Morris Island and Folly Beach. Finally, the construction of warehouses and truck and railway terminals along the coast uses valuable land and seriously alters the shoreline and natural shoreline processes.

FOOD

Coastal people have always relied on the adjacent water for food. For many people there may be no other available sources of food, and for many others the

ocean is being touted as the source of food for the future. Environmentalists foresee some significant problems with this on several levels. First of all, the open ocean is not an environmentally efficient source of food since most of its edible inhabitants feed at a high trophic level. This means that there are many steps between the marine plants at the bottom of the food chain and the edible fish near the top. Shell fish and marine plants are closer to the bottom of the food chain. However, the second significant problem is pollution.

Humans have dumped waste into the ocean for centuries and continue to do so. Though this has led to significant levels of pollution in all parts of the ocean, the problem is and always has been greatest along coats where waters and shallow and sources of pollution are nearby. These are the waters from which most shell fish is harvested. Many people believe that the solution is marine aquaculture whereby large portions of the coast would be closed off, protected, and used to grow a variety of shell fish and crustaceans. The problem, of course, is that there that are many other demands for the same areas. The most significant demand in many areas is for housing and recreation as increasing numbers of people wish to live or vacation at the coast.

RECREATION

The invention of the American summer beach resort has brought millions of people to the coast to spend a day, a week or even a year. If the people are coming, there must be a places for them to stay, they must have some place to eat, and they must have things to do with their time. To be the most successful, all of this should be within view of the water. The result has been the construction of hotels, cabins, restaurants, marinas, amusement parks, and shopping centers on land that is temporary and transient. In many cases, the construction has included the removal of dunes and ancient beaches so that the ocean is more visible and readily accessible. Coastal legislation and common sense have limited some of the earlier abuses, but an unfortunate vicious circle still remains. If the land is naturally temporary and transient, while simultaneously being very valuable, the landowners feel obliged to take any measures possible to prevent change. These measures include items such as: sea walls built along the back of the beach to keep the waves from reaching beyond that point, groins built perpendicular to the beach to trap and hold sand as it moves along the shore, and jetties built at the mouths of inlets to keep sand from flowing in.

All of these devices interfere with the natural movement of sand along the coast, and in the end contribute to the destruction of the coastline they were designed to protect. Experts agree that successful preservation of valuable and scenic coastline involves retreat from geologically active areas. Only if the natural coastal processes are allowed to operate unimpeded can the coast be preserved.

ENVIRONMENT LAW, POLLUTION AND PROTECTION

Environmental law encompasses a body of regulations and legal principles designed to protect and preserve the natural world, including ecosystems, wildlife, air, water, and land. One of the central concerns of environmental law is pollution control and prevention. Pollution, whether it be air, water, or soil pollution, poses significant threats to environmental and public health. Environmental laws establish standards for emissions and discharges from industrial facilities, vehicles, and other sources to mitigate pollution and safeguard human and ecological well-being. Protection of the environment involves a multifaceted approach that includes regulatory measures, enforcement mechanisms, and conservation efforts. Environmental laws often address issues such as waste management, hazardous substances, deforestation, habitat destruction, and climate change mitigation. The enforcement of environmental laws involves government agencies tasked with monitoring compliance, investigating violations, and enforcing penalties against offenders. Civil and criminal penalties may be imposed on individuals or corporations found responsible for environmental harm or non-compliance with regulations. Additionally, environmental litigation plays a vital role in holding polluters accountable and seeking redress for environmental damage. Environmental protection also relies on public participation, education, and advocacy to raise awareness about environmental issues and mobilize collective action. Community involvement, grassroots movements, and international cooperation are essential for addressing global environmental challenges and achieving meaningful progress towards a sustainable future. "In 'Environmental Law: Addressing Pollution and Promoting Protection,' readers explore legal frameworks and strategies aimed at preserving ecosystems and mitigating environmental degradation."

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