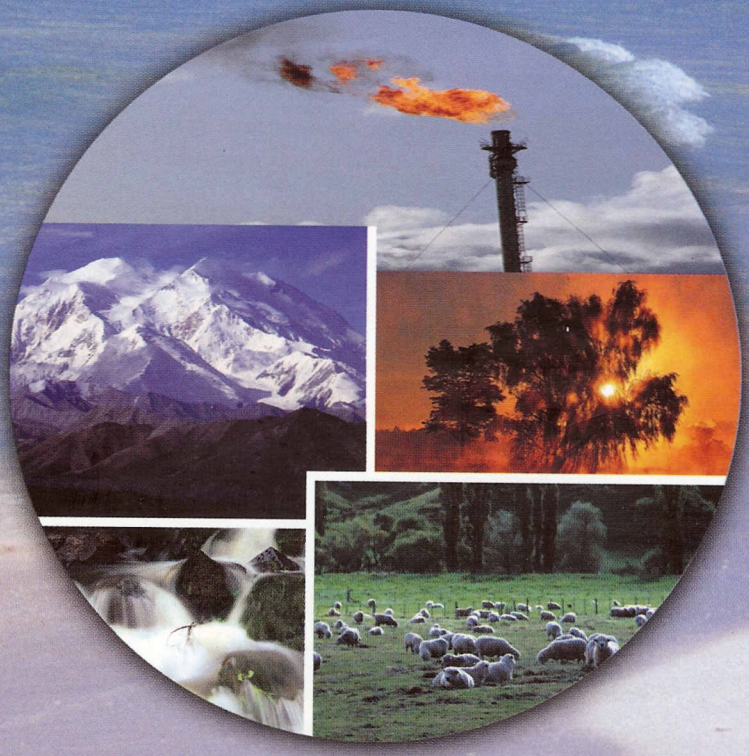
# Environment and Natural Resources

## Ecological and Economic Perspectives



*Editor*
O. P. Singh

# ENVIRONMENT AND NATURAL RESOURCES

## Ecological and Economic Perspectives

*Editor*

*Dr. O.P. Singh*

Centre for Environmental Studies
North-Eastern Hill University
Shillong-793022

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# PREFACE

The rapid pace of population growth and economic development in last century has resulted into large scale natural resource depletion and environmental degradation. As a result, mankind is confronted with various kinds of environmental problems including the air, water and land pollution, water scarcity, deforestation, loss of biodiversity, desertification, flash flood, soil erosion, silting and so on. Simultaneously, large scale and rampant exploitation of the Earth's resources for economic development has now started giving a negative feedback to the same very economic growth.

The terms ozone depletion, green house effect, global warming, climate change, etc. are no longer confined to the glossary of scientific community. Rather, these are commonly discussed issues in the society. Wide spread environmental degradation due to deforestation and pollution coupled with demographic explosion, rapid urbanization and industrialization is affecting not only our present generation but also bound to impact the future generations. The environmental degradation has been perceived as a potential threat to economic growth and well being of the people. Frequent disasters such as flood, draught, landslide, severe cyclonic storms and pollution related health problems affecting our quality of life, cultural assets and economic development. Sustainable supply of food, fiber, fuel and other commodities to expanding world population, and maintaining biodiversity

and clean water and air on earth are some of the big challenges the present society is facing today.

To address these problems and move down the path of sustainable development, a broad-based program of environmental policies and regulations is needed. Such program requires an integrated approach by all concerned stakeholders, so that an amicable solution of the problem can be found out.

The protection and regeneration of the environment is vital for sustainable human development and require understanding of the environment and its various facets that support life. In an attempt to enhance our understanding of the problem and finding solution contemporary topics have been discussed in this book.

The discussed topic shall encourage integration of ecological and economic facets of environment and natural resources and thereby develop a deeper understanding of complex environmental problems needed to solve the problem and move on the path of sustainable development.

The book comprises of five Sections on contemporary topics related to environment and natural resources. The Section One includes 6 introductory Chapters on various aspects of Environment, Natural Resources and Environmental Economics. Three Chapters on air, water and soil pollution and their abatement are included under Section Two on Environmental Degradation and Abatement. The Section Three on Development and Environmental Problems comprises of 3 Chapters and deals with case studies on specific issues. Environmental data collection, analysis and management have become important in view of increasing environmental problems the man facing today. Hence, Section Four is devoted to Environmental Data Collection, Analysis and Management and includes 4 Chapters on Remote Sensing and Geographic Information System, ENVIS and Statistical methods. Section Five is fully devoted to Environmental Impact Assessment and deals with identification and evaluation of potential environmental impacts of anthropogenic and developmental activites.



Important documents such as Rio declaration, List of Indicators of Sustainable Development and a Glossary are included as Appendices.

The chapters, contributed by researchers well recognized in their area of study shall help in improving understanding of environment and natural resources in ecological and economic perspectives. I am confident that this book will be useful for students, researchers, officials and general readers interested in improving environmental quality and moving towards sustainable development.

**O.P. Singh**

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**Section Three: Development and Environmental Problems**



**Section Four: Environmental Data Collection, Analysis and Management**







**Section Five: Environmental Impact Assessment**



**Appendices**

# LIST OF CONTRIBUTORS


1. Dr. N.S. Azad Thakur, Principal Scientist, Division of Entomology, ICAR Research Complex for North Eastern Region, Umiam, Shillong-793103.
2. Dr. S.S. Chaturvedi, Lecturer, Centre for Environmental Studies, North-Eastern Hill University, Shillong-793022.
3. Dr. V.T. Darlong, Scientist, Ministry of Environment & Forest, Government of India, North East Regional Office, Shillong-793012.
4. Dr. G. Das, Reader, Centre for Applied Statistics, North-Eastern Hill University, Shillong-793012.
5. Dr. M.K. Kalita, Professor, Institute of Advance Study in Science & Technology, Khanapara, Guwahati-781022.
6. Dr. S.K. Mishra, Professor, Department of Economics, North-Eastern Hill University, Shillong-793022.
7. Dr. A.C. Mohapatra, Professor, Department of Geography, North-Eastern Hill University, Shillong-793022.
8. Dr. P.P. Nageswara Rao, Deputy Director, North Eastern Space Application Centre, Umiam, Shillong-793013.
9. Dr. S.N. Nandy, Scientist, ENVIS Centre, G. B. Pant Institute of Himalayan Environment & Development, Kosi-Katarmal, Almora-263643.
10. Dr. H.N. Pandey, Professor, Department of Botany, North-Eastern Hill University, Shillong-793022.

11. Dr. Rajasekhara Rao, Scientist, Division of Entomology, ICAR Research Complex for North Eastern Region, Umiam, Shillong-793103.
12. Dr. S.C. Santra, Professor, Department of Environmental Science, University of Kalyani, Nadia-741235.
13. Dr. O.P. Singh, Reader, Centre for Environmental Studies, North-Eastern Hill University, Shillong-793022.
14. Dr. B.K. Tiwari, Professor, Centre for Environmental Studies, North-Eastern Hill University, Shillong-793022.
15. Dr. A.K. Yogi, Deputy Director General, Central Statistical Organization, Ministry of Statistics & Programme Implementation, Government of India, New Delhi-110066.

# ABBREVIATIONS

| | |
|---|---|
| A&C | Abatement and Control |
| BTU | British Thermal Unit |
| CFC | Chlorofluorocarbon |
| CFM | Community Forest Management |
| $CO_2$ | Carbon dioxide |
| dB | Decibel |
| DO | Dissolved oxygen |
| DNA | Deoxyribonucleic acid |
| EC50 | Effective concentration 50 |
| ED50 | Effective dose 50 |
| EIA | Environmental Impact Assessment. |
| EMP | Environmental Management Plan |
| ESP | Electrostatic precipitator |
| FAO | Food and Agriculture Organization |
| FISD | Framework of Indicators of Sustainable Development |
| GIS | Geographic Information Systems |
| GNI | Gross National Income |
| GDP | Gross Domestic Product |
| GNP | Gross National Product |
| GSI | Geological Survey of India |
| HC | Hydrocarbons |
| LD50 | Lethal dose 50 |
| LPG | Liquefied Petroleum Gas |

| | |
|---|---|
| MAB | Man and Biosphere Program |
| MAP | Medicinal and Aromatic Plants |
| MIC | Methyl Isocyanate |
| NAAQMS | National Ambient Air Quality Monitoring Standards |
| NDP | Net Domestic Product |
| NNI | Net National Income |
| NO | Nitric oxide |
| $NO_2$ | Nitrogen dioxide |
| NOx | Oxides of nitrogen or Nitrogen oxide |
| OPEC | Organization of Petroleum Exporting Countries |
| $O_3$ | Ozone |
| PAHs | Polyaromatic hydrocarbons |
| PAN | Peroxyacetyl nitrate |
| PCB | Polychlorinated biphenyl |
| PM | Particulate matter |
| RS | Remote Sensing |
| SAM | Social Accounting Matrices |
| SD | Sustainable Development |
| SNA | System of National Accounts |
| SEA | Socio-Economic Accounts |
| SEEA | System of Integrated Economic & Environmental Accounts |
| SPM | Suspended Particulate Matter |
| SSDA | System of Socio-Demographic Accounts |
| TEV | Total Economic Value |
| TDS | Total Dissolved Solids |
| TSP | Total Suspended Particulate |
| TSS | Total suspended solids |
| UNFAO | United Nations Food and Agriculture Organization |
| UV | Ultraviolet |
| VOC | Volatile organic compound |
| WTA | Willingness to Accept |
| WTP | Willingness to Pay |

SECTION ONE

# Environment, Natural Resources and Environmental Economics

and monetary terms. A detailed physical flow analysis may lead to hundreds of different products or substances being created. To communicate the results more effectively, the flow accounts require aggregation. It is possible to present physical flow accounts at different levels of aggregation.

Purpose of flow accounts is also to provide information to enable the construction of environmental performance indicators. These help assist the analysis of the environmental impacts resulting from certain economic activities, such as domestic consumption and production, and international trade. Flow accounts are often used to show how 'resource efficient' the economy is, and how efficiency has changed for particular material and industrial sectors.

## ACKNOWLEDGEMENT

The information in this chapter is compiled from various websites. The author is grateful to these websites including the websites of UNEP and UNSTAT.

Chapter 6

# CONSERVATION OF NATURAL RESOURCES AND SUSTAINABLE DEVELOPMENT

*B.K. Tiwari*

## INTRODUCTION

In social and regional context, development is often understood as a change for better, improvement, growth or progress. It is studied in two broad categories viz., social, which includes health, education, family welfare, literacy, child mortality and nutrition and economic, which includes per capita income, gross domestic product, employment, industrialization, infrastructure etc. During recent years ecological development has also emerged as an important organ of development which deals with the health of natural systems and state of natural resources like forest, water bodies, soils and levels of environmental pollution and its interactions with the socio-economic development.

The term development is understood differently by different people. For a farmer development means better availability of water, power, fertilizer and pesticides so that he can reap a good harvest from his fields. From the perspective of an industrialist a developed region should have good roads,

telecommunication, market and banking facilities. An area with less law and order problem and better communal harmony may be considered developed in the opinion of an administrator. In the eyes of an unemployed youth development may mean more jobs. An area rich in natural resources, having clean air, pristine forests and unpolluted waters may be the most developed place in the opinion of an environmentalist. So an area can be considered developed or underdeveloped depending on the perspective of the person. However, for a common man development generally means better standard of living which often reflects sum total of all components and facets of development discussed above.

Like development, sustainable development is one the most debated and at times misunderstood term of present times. It aims to provide for the economic, social and ecological well being of present generation without compromising the need of future generations. It is seen more of as a concept than a reality. It talks about the needs of future generations which are almost impossible to predict or even to imagine. For instance, our ancestors some 200 years ago could in no way have imagined about the needs and life style of present generation. So how can we? Therefore, many consider it as an ideal and often see it as an unachievable goal. In fact no one truly knows what sustainable development is, because we cannot point to any examples where it has occurred. There is a general lack of unanimity on how to equitably meet developmental and environmental needs of present and future generations. Ecological, economic and social systems constitute the three pillars of sustainable development. Strength, harmony and balanced growth of these pillars determine the sustainability of development. A broad understanding of sustainable development is depicted in Figure 1.

For the purpose of this article the sustainable development shall be treated as a sort of total development that improves social, economic, ecological as well as political well being of the people and where the standard of living of people gets better while the natural resource base is not depleted beyond the level of regeneration. This may be represented in the form



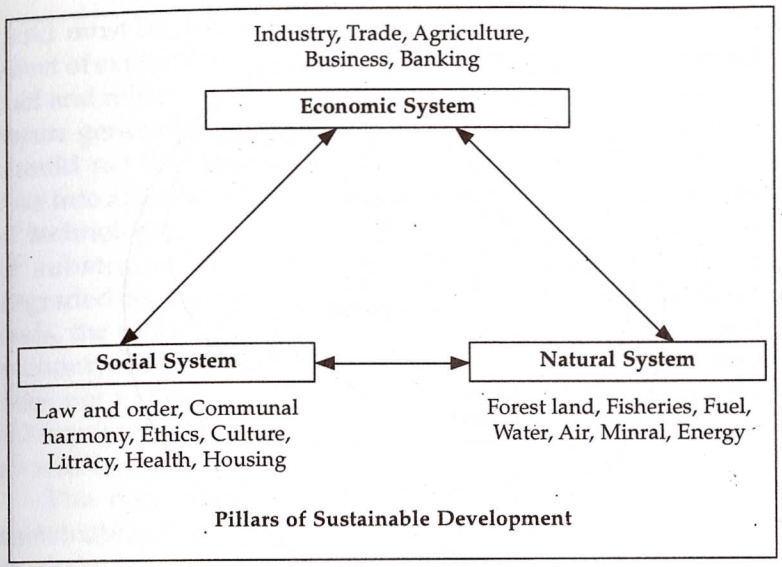


**Figure 1: Interdependence of social, economic and natural systems**

of a model integrating conservation of natural resources, human needs and sustainable economic growth as shown below in Figure 2. This model depicts that sustainable development is a function of judicious use of natural resources viz., forest, soil, fisheries, minerals and energy for meeting the basic needs and to provide ingredients for economic growth. In the subsequent part of this article an attempt has been made to highlight the issues that need to be taken care for promoting sustainability of human and natural systems.

## NATURAL RESOURCE AND SUSTAINABLE DEVELOPMENT

The term natural resource refers to a wide variety of resources that are directly or indirectly employed in production. It is said to include those "ecological factors in production or consumption which owe their origin and existence to natural phenomena or to processes that occur automatically in nature".

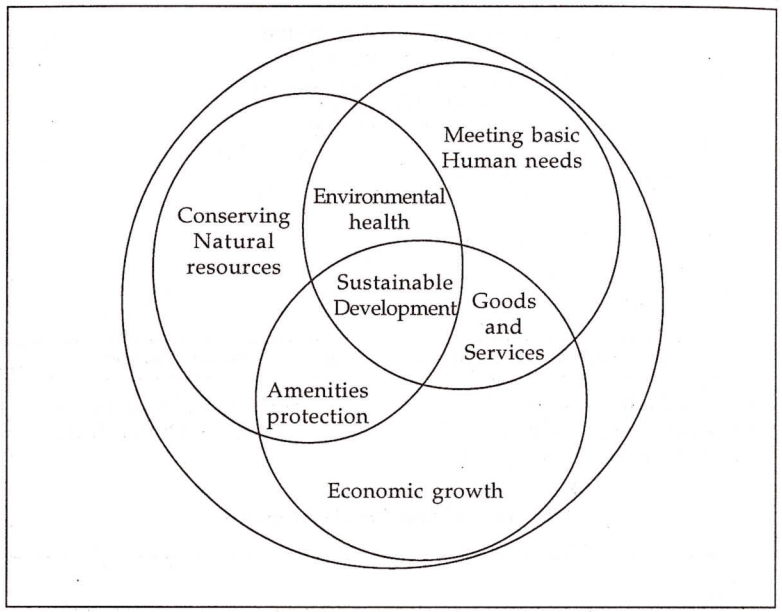


**Figure 2: Model for integrating conservation of natural resources, human needs, economic growth and sustainable development**

Natural resources are considered by some as god given and others as originating from biological, chemical and geological processes that cannot be controlled at will. Though natural resources exists as stocks, they are said to possess one of the two following features — (1) their maximum stock is fixed, (2) the available stock may change at a "natural", "biological" or "biochemical" rate. This rate varies over time but the biological or biochemical factors will prescribe a maximum rate of change. Land area, metal ores, fossil fuels etc., are all examples of resources possessing the first characteristic while forest, fish stocks, natural flora and fauna, fresh air and water supplies etc., exemplify the second characteristic of natural resources.

Renewable resources like forests and fish stocks need not be depleted provided the rate of use is within the limits of regeneration and natural growth. But most renewable resources are part of a complex and interlinked ecosystem, and maximum



yield must be defined after taking into account system wide effect of exploitation. As for non-renewable resources like fossil fuel and minerals, their use reduces the stock available for the future generation. But this does not mean that such resources should not be used. In general the rate of depletion should take into account the criticality of that resource, the availability of technologies for minimizing depletion, and the likelihood of substitutes being available. Thus land should not be degraded beyond reasonable recovery. With minerals and fossil fuels, the rate of depletion and the emphasis on recycling and economy of use should be calibrated to ensure that the resource does not run out before acceptable substitutes are available. SD requires that the rate of depletion of non renewable resource should fore close as few future options as possible.

The natural resource sectors are at the forefront of sustainable development issues. Industry has made important investments and innovations to improve environmental performance and to improve sustainable resource management practices. Communities have begun to find alternative and innovative solutions in competing land-use decisions, and have become quite sophisticated in their utilization of technologies to support their arguments. Governments have begun to address waste management issues and are finding innovative ways to reduce greenhouse gas emissions. Broad stakeholder participation in the decisions regarding the development and use of natural resources is becoming the norm rather than the exception. Significant challenges however remain to be tackles:

## POPULATION STABILIZATION

The pattern of population growth is often related to the level of development. Amongst many developing societies, the natality and mortality is determined by the stage of development. The lowest stage of development is characterized by high natality and high mortality resulting into slow population growth. After a certain level of development is achieved the mortality drops while natality remains high. The population growth is highest during this period. The

population tends to stabilize by low level of natality and low level of mortality when the society achieves higher level of social and economic development. Population stabilization is therefore seen as a product of development. Most states of India are still either in stage one of development and thus the growth is very slow for example parts of Arunachal Pradesh or are in the second stage of development and thus experiencing high growth rate for example the state of Nagaland.

Any policy or plan aimed at making the development of India more sustainable, needs to influence the population growth in a manner that it stabilizes faster and also at a low level. This will ensure higher per capita availability of natural resources. Indian economy has a large primary sector with minimal capacity of employment generation. Growth of secondary and tertiary sectors has been slow due obvious reasons. Thus the natural resources like soil, water, forests, minerals etc., were exploited to provide livelihood to the vast growing population often resulting into unsustainable and wasteful use of resources. High population density superimposed with low level of socio-economic development resulted into poor management of natural resources. This is manifested in the form of sprawling wastelands, polluted water bodies, unprecedented human migration, depleting bioresource, growing unemployment and stagnant agricultural growth. Therefore, population stabilization becomes a prime concern for achieving the goal of sustainable development. Population stabilization can be achieved through rapid socio-economic development. Development planners must not wait until the population stabilizes by itself as it may take a long time and by then the total population will be too large and natural resources shall be in a considerably depleted stage. In such a condition raising the standard of living of every citizen may prove to be even more difficult.

## EFFICIENT USE OF NATURAL RESOURCES

Natural resources are the most important ingredient for development of any nation as they provide raw material and



energy needed for maintaining the pace of development. Natural resources are the ecological capital provided by the nature like a one time grant. Most natural resources are finite commodity and non renewable in short term. Even renewable resources like forests and grasslands can become nonrenewable if not managed properly. In order to derive maximum benefit for maximum number of people, inventorying and long term planning for resource use is a must. Efficient use of natural resources needs technological and managerial inputs. Involvement of people in natural resource management and raising awareness about ecological benefits of nature conservation are desirable for improving efficiency of resource use. While efficient use of ecological capital can help in accelerating the pace of socio-economic development, its misuse may cause ecological disaster. Figure 3 depicts the interrelations of various components of development and shows how they are dependent on the natural resources.

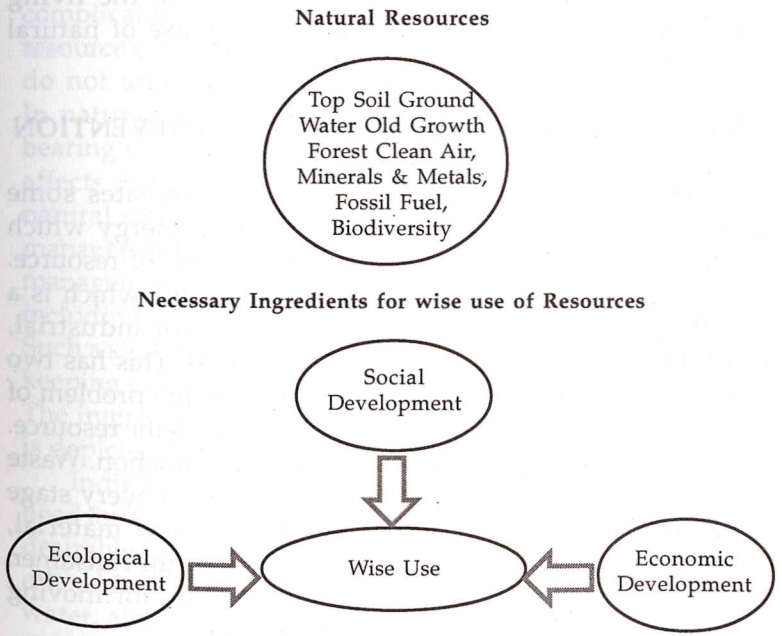


**Figure 3: Interrelationship of social, economic and ecological development and its dependence on natural resources**

India is rich in several natural resources. It has huge deposits of major and minor minerals viz., coal, limestone, petroleum, silliminite and several minor minerals, plenty of surface and ground water, fertile soil, biodiversity rich forests, huge domesticated germplasm, plenty of sunshine and climate favourable plant and animal life. The ecological capital of the country need to be used judiciously for short term and long term needs. The efficient utilization of resources means plugging of wastage, encouraging reuse, recycle, and waste use, and its protection and preservation where ever necessary. Natural resources provide raw materials for economic system and thus they are the backbone of economic development. Economic development and natural resource management can go hand in hand and can even promote each other if managed and planned on the principles of sustainable development. There is an urgent need of bringing out a policy guideline for natural resource management of the country aiming at balanced growth of economy and improving the living conditions of the people through judicious use of natural resources.

## WASTE REDUCTION AND POLLUTION PREVENTION

Economic production system invariably emanates some quantity of waste. Waste is the material or energy which remains unused or is generated during the use of resource. Often waste is looked as unwanted or unusable which is a wrong notion. In fact most wastes whether of industrial, agricultural or of domestic origin can be used. This has two benefits, it reduces the waste thereby reduces the problem of waste disposal, prevents pollution and conserves the resource. This type of production is known as clean production. Waste reduction and pollution prevention is needed at every stage of product life cycle i.e. from extraction of raw material, production process and final use and disposal by the consumer. This is the most important management option for moving toward the goal of sustainable development.



In India the extraction and utilization of most natural resources are being carried out using out-dated and primitive technologies. This is causing colossal waste of vital resources and polluting near by natural systems. Extraction of coal and lime stone in Meghalaya is a glaring example of unsustainable natural resource management.

## INTEGRATED NATURAL RESOURCE MANAGEMENT SYSTEM

In nature various components like land, water bodies, forests, grasslands, agriculture and horticulture are interdependent and interact with each other. Various natural resources are found dispersed in a mosaic fashion as an element of the landscape. However, for our convenience we have separated them by putting artificial boundaries and often evolve separate management plans and create separate departments responsible for their management. The matter becomes more complicated if there is a lack of coordination among different resource managers. The personnel deployed in one sector often do not understand the problems concerning other sectors. In natural systems, management of one component has a bearing over the other and mismanagement of one adversely affects the other. The best example of interdependence of natural resources is the case of forest, water and soil. Sound management of natural resources therefore, needs an integrated management system that takes care of all elements of landscape including a built in mechanism of monitoring and evaluation. Such a system will help conservation and best use of resources keeping in view the short and long term interest of the society. The interdependence of economic system and natural system is depicted in the Figure 4.

India is extremely rich in natural resources and therefore a need for an integrated management of natural resources is most desirable in this region. Unplanned extraction of forest and other bioresource, unscientific mining, poor management of water, almost total lack of land use plan are some important areas that need to be tackled on priority for making the resource use more sustainable. There is a need to inculcate the concept

The Economic System and the Natural System

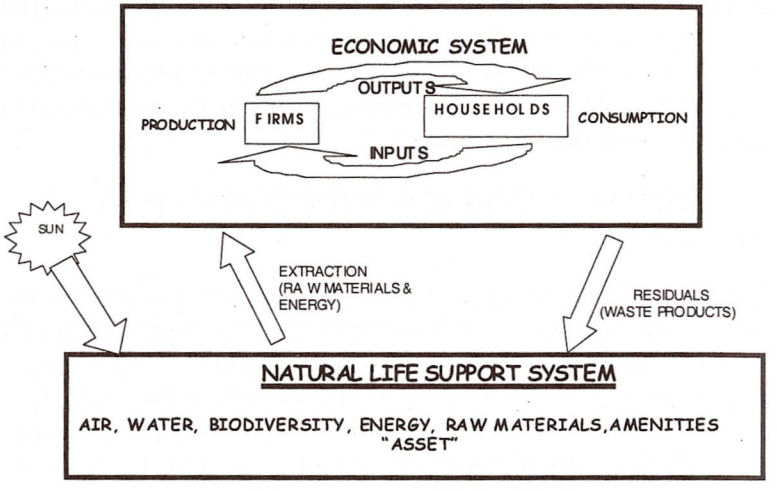


**Figure 4: Working of economic system and its relation with natural system**

of integrated management of natural resources in the minds of planners and policy makers.

## DETERMINING ENVIRONMENTAL LIMITS

The economic system depends on natural system for the raw materials and also for disposal of the wastes. In many instances the economic systems tend to exceed the limit of extraction of raw materials or disposal of wastes. This causes scars and irreparable damage to the natural system and human environment in short run and may result in collapse of economic system in long run. Therefore, before start of any economic activity it is required to determine the environmental limit i.e. how much can be safely extracted and how much waste can be safely disposed. The determination of environmental limit is generally taken as an on going process and should be a part of environmental monitoring. The environmental limits can be enhanced through injection of advanced technology or through improved environmental management (Figure 5). A glaring example of ignoring the



| *Wise Use* | *Inputs* |
|---|---|
| • Reuse | Technology |
| • Efficient Use | Management |
| • Waste Minimisation | Education |
| • Waste Use | Information |
| • Recycle | Communication |
| • Substitution | Cooperation |
| • Market Forces | Finances |
| • Transport and Trade | |

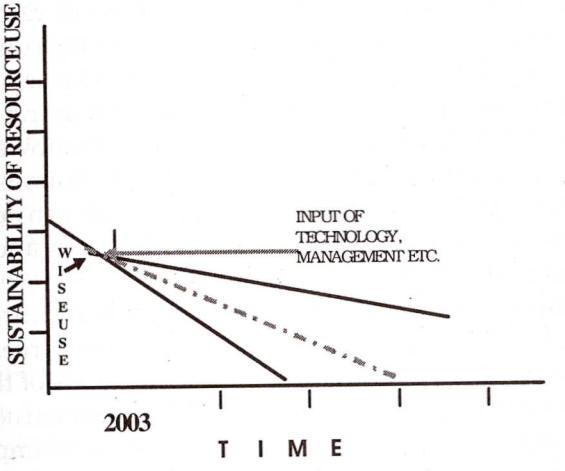


**Figure 5: Enhancement of sustainability through wise use of resources and inputs to the system**

environmental limits is seen in India where huge quantity of timber has been extracted from the natural forests without proper restoration of the ecosystems and large areas of primary forests were cleared for tea plantation without determining any limit or assessing their possible impact on the environment. Similarly several paper mills and ply wood industries were established which used the bamboo and soft wood resources, mostly unsustainably, causing irreparable damage to the natural system of the region and in due course several of these industries also vanished. It is required that in future the prior determination of environmental limits be made mandatory for all economic activities.

## REFINING MARKET ECONOMY

Market acts like a double edged sword when it comes to management of natural resources and conservation of environment. If used properly it can help develop the resource base, provide maximum benefit to the society and even promote environmental conservation. However, market is often profit driven and thus it promotes activities which are beneficial to its players even at the cost of environment and development. Market promotes exploitation of resources for production of goods and services and therefore, conservation and sustainability are seldom its priority. Market therefore, needs to be refined so as to promote sustainable and judicious use of resources, social justice and equity. Empowerment of local people and building of community institutions to act as watch dogs and shortening of market channels can be possible interventions making the market eco-friendly and akin to sustainable development.

Northeastern India is an example where unregulated market has caused havoc to its natural resources during past century. The natural resources and products of the region have a vast market outside the region. Poor infrastructure and prevailing socio-political conditions have been an impediment in development of large businesses and establishment of industries in the region. The remoteness of the region caused shrinkage of potential number of entrepreneurs and only those who could afford to take a certain degree of risks and relatively more enterprising took the job. In such conditions, the middlemen and all market players worked on very high profit margins. Local governments and communities had little say in the market until few decades ago. This resulted into unsustainable exploitation of natural resources and degradation of environment. This market economy promoted the exploitation of natural resources of the region mostly for the benefit of big business houses with little benefit accruing to the local communities. Serious policy interventions are required for refining the markets with an aim to make them



promote development without degrading the natural system of the region.

## HUMAN RESOURCE DEVELOPMENT

Education, training and level of skill of people are the indices of development. The development of human resource provides space and creates conditions suitable for improved management of natural resources and enables the communities to take well informed decisions. It enhances the level of understanding and broadens the horizon of the people. It improves the availability of man power to take up the jobs related to management and conservation of resources. Implementation of any programme for sustainable utilization of natural resources can be better implemented in a community which is educated and well informed. In fact a certain level of human resource development is a must for guiding the development toward a path which is more sustainable. Recent initiatives of a local community for ecorestoration of mining affected areas of Rymbai village in Jaintia Hills, (Meghalaya) can be attributed to the education and other social development activities in the village. This is a glaring example of human resource development promoting natural resource management.

## PERCEPTION AND ATTITUDINAL CHANGES

The sustainability of development is to a great extent a function of sound development planning and efficient management of available resources. The perception and attitude of people is very important for doing this, as sustainable development often requires sacrificing short term gains in the interest of long term benefits. Also, at times it may warrant foregoing self interests in favour of society. All this requires right kind of motivation and attitudinal change of the society and individuals and even educate them in environmental ethics. To achieve intra and intergenerational equity, the basic tenet of sustainable development, the society's attitude toward the resources need to be changed. Every individual needs to be motivated to think

that all that is available is not meant for him alone; the other sections of the society and even those yet to be born also have a share in it.

People in earlier days, in general have been considerate to the nature and fellow people. Strong community bonds and ready to help attitudes were very common among most indigenous societies. Accumulation of wealth and lavish living has not been a part of the Indian culture. This type of attitude favour sustainable and equitable use of resources. However, this perception and attitude is eroding rapidly in several parts of the country. It is therefore, required to revitalize the local traditions and educate the people about the value of ethics and positive attitude toward environment and natural resources.

## ENHANCING SUSTAINABILITY AND RESOURCE AVAILABILITY

The availability of resource and sustainability of development can be enhanced through wise use which can be promoted through reuse, efficient use, waste minimization, waste use, recycling, product substitution, market refinement and improved trade and commerce. Input of technology, management, education, information, communication, co-operation and financial resources can also enhance the sustainability of resource use. A detailed treatment of all these is beyond the scope of this article, however some of these are briefly discussed hereunder.

### Recycling

It is the reprocessing of discarded materials into new, useful products. Some recycling processes reuse materials for the same purposes; for instance, old aluminium cans and glass bottles are usually melted and recast into new cans and bottles. Other recycling processes turn old materials into entirely new products. Old tyres, for instance, are shredded and turned into rubberized road surfacing, newspapers become cellulose



insulation, kitchen wastes become valuable soil amendments, and steel cans become new automobiles and construction materials. The benefits of recycling are — it saves money, energy, raw material and land space, while also reducing pollution encourages individual awareness and responsibility for the refuse produced, cut the waste volume drastically and reduces the pressure on disposal system, lowers our demand for raw resources and also reduces energy consumption and air pollution.

### Reuse

It is the cleaning and reusing of materials in their present form. It is better than recycling or composting as it save the cost and energy of remaking them into something else. For example, auto parts are regularly sold from junkyards especially for older car models, glass and plastic bottles are routinely returned to beverages producers for washing and refilling.

### Energy from waste

In land fill, organic municipal waste is decomposed by micro-organisms generating huge amount of methane ($CH_4$), which contributes to global warming if allowed to escape into the atmosphere. The methane wells in the landfill can be drilled to capture this valuable resource. In another case, waste biofuels (produced from organic materials either directly from plants or indirectly from industrial, commercial, domestic or agricultural wastes) are used for energy generation.

### Composting

It is the biological degradation or breakdown of organic matter under aerobic conditions. The organic compost obtains makes a nutrient rich soil amendment that aids water retention, slows down soil erosion, enhances the crop yield and reduces use of energy and materials for production of fertilizers.

### Sustainable agriculture

It aims to produce food and fibre on a sustainable basis and repair the damage caused by destructive practices. Alternative methods are developed through scientific research; others are discovered in traditional cultures and practices which are nearly forgotten in our mechanization and industrialization of agriculture. Planting of cover crop such as rye, alfalfa or clover immediately after harvest is done to hold and protect the soil from erosion. Mulching with manure, wood chips, straw, seaweed, leaves and other natural products are also practiced in some regions. For combating pests and diseases integrated pest management that combines crop rotation, trap crops, natural repellents and biological controls are used in place of synthetic pesticides.

## SUSTAINABLE AGRICULTURE IN CUBA: A CASE STUDY

Cuba's agricultural system is based on a combination of old and new ideas. Diverse crops suitable to local micro-climates, soil types and human nutritional needs have been adopted. Natural, renewable energy sources such as wind, solar and biomass fuels are being substituted for fossil fuels. In case of soil management, organic fertilizers, livestock manure, green manure crops, composted municipal garbage industrial-scale cultivation of high quality humus in earthworms farms are use to replenish soil fertility.

Pests are suppressed by crop rotation and biological controls rather than chemical pesticides. For example, the parasitic fly (*Lixophaga diatraeae*) controls sugarcane borers; wasps in the genus *Trichogramma* feed on the eggs of grain weevils, predatory ants (*Pheidole megacephala*) attacks sweet potato weevils. Pest control also involves use of bio-pesticides such as *Bacillus thuringiensis*, which are poisonous or repellent to crop pests. Finally integrated pest management includes careful monitoring of crops and measures to build population of native beneficial organisms and to enhance the vigor and defenses of crop species.



Cuba is now on a sustainable path and is a world leader in sustainable agriculture. It could serve as a model for others who surely will face a similar transition when our supplies of fossil fuels run out.

## VISION OF A SUSTAINABLE FUTURE

People in all regions of the country — individuals, organizations, communities and institutions should embrace and contribute to sustainable development by making informed decisions that have environmental and economic considerations. The natural resource-related sectors and allied industries should be dynamic, innovative and profitable, delivering goods and services which are environmentally and socially responsible. People should be able to have access to the highest quality information, science and technology and use land-based and offshore- resources, and resource-based products and services wisely and efficiently to ensure positive opportunities, now and for the future. The vision integrates social, economic and environmental considerations which is achievable through co-operation and collaboration among all stakeholders and partners.

In order to develop measurable actions that will contribute towards this vision, it can be disaggregated into three key elements. This approach will help us to realize the vision by working at three different levels, in a holistic manner. There is a local and global dimension to each level of the approach.

The core of the vision, the smallest circle, acknowledges that all stakeholders locally and globally, make decisions about how to better enable natural resource activities to contribute to sustainable development. Achieving the vision of a sustainable future will require that the right conditions are in place, that barriers are addressed and that new opportunities are realized through increased capacity for sustainable development. The second circle, in the middle, reaches beyond decisions and capacity, to maximize social, environmental and economic benefits for all. The outer circle refers to how, in the process of realizing the vision, the planetary biophysical limits

must be recognized and the processes that facilitate social and economic activities be grounded in accessible knowledge and good governance. To this end, this circle reflects the need for a stewardship approach that will enable future generations to enjoy opportunities and continued health and well-being.

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SECTION TWO

# Environmental Degradation and Abatement

Appendix I

# RIO DECLARATION ON ENVIRONMENT AND DEVELOPMENT

(Excerpts of report of the United Nations Conference on the Human Environment, Stockholm, 5–16 June 1972)

The United Nations Conference on Environment and Development, having met at Rio de Janeiro from 3 to 14 June 1992, reaffirming the declaration of the United Nations Conference on the Human Environment, adopted at Stockholm on 16 June 1972, and seeking to build upon it, with the goal of establishing a new and equitable global partnership through the creation of new levels of cooperation among States, key sectors of societies and people, working towards international agreements which respect the interests of all and protect the integrity of the global environmental and developmental system, recognizing the integral and interdependent nature of the Earth, our home, proclaims that:

**PRINCIPLE 1**

Human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature.

**PRINCIPLE 2**

States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental and developmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.

**PRINCIPLE 3**

The right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations.

**PRINCIPLE 4**

In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it.

**PRINCIPLE 5**

All States and all people shall cooperate in the essential task of eradicating poverty as an indispensable requirement for sustainable development, in order to decrease the disparities in standards of living and better meet the needs of the majority of the people of the world.

**PRINCIPLE 6**

The special situation and needs of developing countries, particularly the least developed and those most environmentally vulnerable, shall be given special priority. International actions in the field of environment and development should also address the interests and needs of all countries.



**PRINCIPLE 7**

States shall cooperate in a spirit of global partnership to conserve, protect and restore the health and integrity of the Earth's ecosystem. In view of the different contributions to global environmental degradation, States have common but differentiated responsibilities. The developed countries acknowledge the responsibility that they bear in the international pursuit to sustainable development in view of the pressures their societies place on the global environment and of the technologies and financial resources they command.

**PRINCIPLE 8**

To achieve sustainable development and a higher quality of life for all people, States should reduce and eliminate unsustainable patterns of production and consumption and promote appropriate demographic policies.

**PRINCIPLE 9**

States should cooperate to strengthen endogenous capacity-building for sustainable development by improving scientific understanding through exchanges of scientific and technological knowledge, and by enhancing the development, adaptation, diffusion and transfer of technologies, including new and innovative technologies.

**PRINCIPLE 10**

Environmental issues are best handled with participation of all concerned citizens, at the relevant level. At the national level, each individual shall have appropriate access to information concerning the environment that is held by public authorities, including information on hazardous materials and activities in their communities, and the opportunity to participate in decision-making processes. States shall facilitate and encourage public awareness and participation by making

information widely available. Effective access to judicial and administrative proceedings, including redress and remedy, shall be provided.

**PRINCIPLE 11**

States shall enact effective environmental legislation. Environmental standards, management objectives and priorities should reflect the environmental and development context to which they apply. Standards applied by some countries may be inappropriate and of unwarranted economic and social cost to other countries, in particular developing countries.

**PRINCIPLE 12**

States should cooperate to promote a supportive and open international economic system that would lead to economic growth and sustainable development in all countries, to better address the problems of environmental degradation. Trade policy measures for environmental purposes should not constitute a means of arbitrary or unjustifiable discrimination or a disguised restriction on international trade. Unilateral actions to deal with environmental challenges outside the jurisdiction of the importing country should be avoided. Environmental measures addressing transboundary or global environmental problems should, as far as possible, be based on an international consensus.

**PRINCIPLE 13**

States shall develop national law regarding liability and compensation for the victims of pollution and other environmental damage. States shall also cooperate in an expeditious and more determined manner to develop further international law regarding liability and compensation for adverse effects of environmental damage caused by activities within their jurisdiction or control to areas beyond their jurisdiction.



**PRINCIPLE 14**

States should effectively cooperate to discourage or prevent the relocation and transfer to other States of any activities and substances that cause severe environmental degradation or are found to be harmful to human health.

**PRINCIPLE 15**

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.

**PRINCIPLE 16**

National authorities should endeavour to promote the internalization of environmental costs and the use of economic instruments, taking into account the approach that the polluter should, in principle, bear the cost of pollution, with due regard to the public interest and without distorting international trade and investment.

**PRINCIPLE 17**

Environmental impact assessment, as a national instrument, shall be undertaken for proposed activities that are likely to have a significant adverse impact on the environment and are subject to a decision of a competent national authority.

**PRINCIPLE 18**

States shall immediately notify other States of any natural disasters or other emergencies that are likely to produce sudden harmful effects on the environment of those States. Every effort shall be made by the international community to help States so afflicted.

**PRINCIPLE 19**

States shall provide prior and timely notification and relevant information to potentially affected States on activities that may have a significant adverse transboundary environmental effect and shall consult with those States at an early stage and in good faith.

**PRINCIPLE 20**

Women have a vital role in environmental management and development. Their full participation is therefore essential to achieve sustainable development.

**PRINCIPLE 21**

The creativity, ideals and courage of the youth of the world should be mobilized to forge a global partnership in order to achieve sustainable development and ensure a better future for all.

**PRINCIPLE 22**

Indigenous people and their communities and other local communities have a vital role in environmental management and development because of their knowledge and traditional practices. States should recognize and duly support their identity, culture and interests and enable their effective participation in the achievement of sustainable development.

**PRINCIPLE 23**

The environment and natural resources of people under oppression, domination and occupation shall be protected.

**PRINCIPLE 24**

Warfare is inherently destructive of sustainable development. States shall therefore respect international law providing



protection for the environment in times of armed conflict and cooperate in its further development, as necessary.

**Principle 25**

Peace, development and environmental protection are interdependent and indivisible.

**PRINCIPLE 26**

States shall resolve all their environmental disputes peacefully and by appropriate means in accordance with the Charter of the United Nations.

**PRINCIPLE 27**

States and people shall cooperate in good faith and in a spirit of partnership in the fulfilment of the principles embodied in this Declaration and in the further development of international law in the field of sustainable development.

*Source*: UNEP website 2003.

Appendix II

# AGENDA 21 INDICATORS OF SUSTAINABLE DEVELOPMENT

| *Chapter of Agenda 21* | *Driving Force indicators* | *State indicators* | *Response indicators* |
|---|---|---|---|
| **Economic Category** | | | |
| Chapter 3: Combating poverty | • Unemployment rate | • Head count index of poverty<br>• Poverty gap index<br>• Squared poverty gap index<br>• Gini index of income inequality<br>• Ratio of average female wage to male wage | |
| Chapter 5: Demographic dynamics and sustainability | • Population growth rate<br>• Net migration rate<br>• Total fertility rate | • Population density | |
| Chapter 36: Promoting education, public awareness and training | • Rate of change of school-age population<br>• Primary school enrolment ratio (gross and net)<br>• Secondary school enrolment ratio (gross and net)<br>• Adult literacy rate | • Children reaching grade 5 of primary education<br>• School life expectancy<br>• Difference between male and female school enrolment ratios<br>• Women per hundred men in the labour force | • GDP spent on education |
| Chapter 6: Protecting and promoting human health | | • Basic sanitation: Percent of population with adequate excreta disposal facilities<br>• Access to safe drinking water<br>• Life expectancy at birth<br>• Adequate birth weight<br>• Infant mortality rate<br>• Maternal mortality rate<br>• Nutritional status of children | • Immunization against infectious childhood diseases<br>• Contraceptive prevalence<br>• Proportion of potentially hazardous chemicals monitored in food<br>• National health expenditure devoted to local health care<br>• Total national health expenditure related to GNP |
| Chapter 7: Promoting sustainable human settlement development | • Rate of growth of urban population<br>• Per capita consumption of fossil fuel by motor vehicle transport<br>• Human and economic loss due to natural disasters | • Percent of population in urban areas<br>• Area and population of urban formal and informal settlements<br>• Floor area per person<br>• House price to income ratio | • Infrastructure expenditure per capita |
| Chapter 2: International cooperation to accelerate sustainable development in countries and related domestic policies | • GDP per capita<br>• Net investment share in GDP<br>• Sum of exports and imports as a percent of GDP | • Environmentally adjusted Net Domestic Product<br>• Share of manufactured goods in total merchandise exports | |
| Chapter 4: Changing consumption patterns | • Annual energy consumption<br>• Share of natural-resource intensive industries in manufacturing value-added | • Proven mineral reserves<br>• Proven fossil fuel energy reserves<br>• Lifetime of proven energy reserves<br>• Intensity of material use<br>• Share of manufacturing value-added GDP<br>• Share of consumption of renewable energy resources | |

... contd. Appendix II

| Chapter of Agenda 21 | Driving Force indicators | State indicators | Response indicators |
|---|---|---|---|
| Chapter 33: Financial resources and mechanisms | • Net resources transfer/GNP<br>• Total ODA given or received as a percentage of GNP | • Debt/GNP<br>• Debt service/export | • Environmental protection expenditures as a percent of GDP<br>• Amount of new or additional funding for sustainable development |
| Chapter 34: Transfer of environmentally sound technology, cooperation and capacity-building | • Capital goods imports<br>• Foreign direct investments | • Share of environmentally sound capital goods imports | • Technical cooperation grants |
| **Environmental category** | | | |
| Chapter 18: Protection of the quality and supply of freshwater resources | • Annual withdrawals of ground and surface water<br>• Domestic consumption of water per capita | • Groundwater reserves<br>• Concentration of faecal coliform in freshwater<br>• Biochemical oxygen demand in water bodies | • Waste-water treatment coverage<br>• Density of hydrological networks |
| Chapter 17: Protection of the oceans, all kinds of seas and coastal areas | • Population growth in coastal areas<br>• Discharges of oil into coastal waters<br>• Releases of nitrogen and phosphorus into coastal waters | • Maximum sustained yield for fisheries<br>• Algae index | |
| Chapter 10: Intergrated approach to the planning and management of land resources | • Land use change | • Changes in land condition | • Decentralized local-level natural resource management |



| | | | |
|---|---|---|---|
| Chapter 12: Managing fragile ecosystems: combating desertification and drought | • Population living below poverty line in dryland areas | • National monthly rainfall index<br>• Satellite derived vegetation index<br>• Land affected by desertification | |
| Chapter 13: Managing fragile ecosystems: sustainable mountain development | • Population change in mountain areas | • Sustainable use of natural resources in mountain areas<br>• Welfare of mountain populations | |
| Chapter 14: Promoting sustainable agriculture and rural development | • Use of agricultural pesticides<br>• Use of fertilizers<br>• Irrigation % of arable land<br>• Energy use in agriculture | • Arable land per capita<br>• Area affected by salinization and waterlogging | • Agricultural education |
| Chapter 11: Combating deforestation | • Wood harvesting intensity | • Forest area change | • Managed forest area ratio<br>• Protected forest area as a percent of total forest area |
| Chapter 15: Conservation of biological diversity | | • Threatened species as a percent of total native species | • Protected area as a percent of total area |
| Chapter 16: Environmentally sound management of biotechnology | | | • R&D expenditure for biotechnology<br>• Existence of national biosafety regulations or guidelines |
| Chapter 9: Protection of the atmosphere | • Emissions of greenhouse gases<br>• Emissions of sulphur oxides<br>• Emissions on nitrogen oxides<br>• Consumption of ozone depleting substances | • Ambient concentrations of pollutants in urban areas | • Expenditure on air pollution abatement |
| Chapter 21: Environmentally sound management of solid wastes and sewage-related issues | • Generation of industrial and municipal solid waste<br>• Household waste disposed per capita | | • Expenditure on waste management<br>• Waste recycling and reuse<br>• Municipal waste disposal |

contd...

... contd. Appendix II

| *Chapter of Agenda 21* | *Driving Force indicators* | *State indicators* | *Response indicators* |
|---|---|---|---|
| Chapter 19: Environmentally sound management of toxic chemicals | | • Chemically induced acute poisonings | • Number of chemicals banned or severely restricted |
| Chapter 20: Environmentally sound management of hazardous wastes | • Generation of hazardous wastes<br>• Imports and exports of hazardous wastes | • Area of land contaminated by hazardous wastes | • Expenditure on hazardous waste treatment |
| Chapter 22: Safe and environmentally sound management of radioactive wastes | • Generation of radio active wastes | | |
| **Institutional category** | | | |
| Chapter 8: Integrating environment and development in decision-making | | | • Sustainable development strategies<br>• Programme of integrated environmental and economic accounting<br>• Mandated Environmental Impact Assessment<br>• National councils for sustainable development |
| Chapter 35: Science for sustainable development | | • Potential scientists and engineers per million population | • Scientists and engineers engaged in R&D per million population<br>• Expenditure on R&D as a percent of GDP |



| | | | |
|---|---|---|---|
| Chapter 37: National mechanisms and international cooperation for capacity-building in developing countries | | | |
| Chapter 38: International institutional arrangements | | | |
| Chapter 39: International legal instruments and mechanisms | | | • Ratification of global agreements<br>• Implementation of ratified global agreements |
| Chapter 40: Information for decision-making | | • Main telephone lines per 100 inhabitants<br>• Access to information | • Programmes for national environmental statistics |
| Chapter 23–32: Strengthening the role of major groups | | | • Representation of major groups in national councils for sustainable development<br>• Representatives of ethnic minorities and indigenous people in national councils for sustainable development<br>• Contribution of NGOs to sustainable development |

Appendix III

# LIST OF ENVIRONMENTAL LEGISLATIONS

(Issued in accordance with the Constitution of India to **'protect and improve the environment and to safeguard the forests and wildlife of the country'**)

## GENERAL ENVIRONMENTAL LEGISLATIONS

1986

**The Environment (Protection) Act** authorizes the central government to protect and improve environmental quality, control and reduce pollution from all sources, and prohibit or restrict the setting and/or operation of any industrial facility on environmental grounds.

1986

**The Environment (Protection) Rules** lays down procedures for setting standards of emission or discharge of environmental pollutants.

1989

**Hazardous waste (Management and Handling) Rules** objective is to control generation, collection, treatment, import, storage and handling of hazardous waste.



1989

**The Manufacture, Storage and Import of Hazardous Chemical Rules** defines the terms used in this context, and sets up an Authority to inspect, once a year, the industrial activity connected with hazardous chemicals and isolated storage facilities.

1989

**The Manufacture, Use, Import,, Export and Storage of hazardous Micro-organisms/Genetically Engineered Organisms or Cells Rules** were introduced with a view to protect the environment, nature and health, in connection with the application of gene technology and micro organisms.

1991

**The Public Liability Insurance Act and Rules and Amendment, 1992** was drawn up to provide for public liability insurance for the purpose of providing immediate relief to the persons affected by accident while handling any hazardous substance.

1995

**National environmental Tribunal Act** has been created to award compensation for damages to persons, property and the environment arising from any activity involving hazardous substances.

1997

**The National Environment Appellate Authority Act** has been created to hear appeals with respect to restrictions of areas in which classes of industries etc are carried out or prescribed subject to certain safeguards under the EPA (Environment Protection Act).

1998

**Biomedical waste (Management and Handling) Rules** is a legal binding on the health care institutions to streamline the process of proper handling of hospital waste such as segregation, disposal, collection and treatment.

## LEGISLATIONS FOR PROTECTION OF FOREST AND WILDLIFE

1927

**Indian Forest Act and Amendment 1984** is one of the many surviving colonial statutes. It was enacted to 'consolidate the law related to forest, the transit of forest produce and the duty leviable on timber and other forest produce.

1972

**Wildlife Protection Act, Rules 1973 and Amendment 1991** provides for the protection of birds and animals and for all matters that are connected to it whether it be their habitat or the waterhole or the forest that sustain them.

1980

**The Forest (Conservation) Act and Rules 1981** provides for the protection of and the conservation of the forests.

## LEGISLATIONS FOR PROTECTION OF WATER RESOURCES AND QUALITY

1882

**The Easement Act** allows private rights to use a resource i.e. groundwater, by viewing it as an attachment to the land. It also states that all surface water belongs to the state and is a state property.



1897

**Indian Fisheries Act** establishes two sets of penal offences whereby the government can sue any person who uses dynamite or other explosive substance in any way (whether coastal or inland) with intent to catch or destroy any fish or poisons fish in order to kill.

1956

**The River Boards Act** enables the states to enroll the Central Government in setting up an Advisory River Board to resolve issues in inter state cooperation.

1970

**Merchant Shipping Act** aims to deal with waste arising from ships along the coastal areas within a specified radius.

1974

**The Water (Prevention and Control of Pollution) Act** establishes an institutional structure for preventing and abating water pollution. It establishes standards for water quality and effluent. Polluting industries must seek permission to discharge waste into effluent bodies. The Pollution Control Board (CPCB) was constituted under this act.

1977

**The Water (Prevention and Control of Pollution) Cess Act** provides for the levy and collection of cess or a fees on water consuming industries and local authorities.

1978

**The Water (Prevention and Control of Pollution) Cess Rules** contains the standard definitions and indicate the kind of and location of meters that every consumer of water is required to affix.

**1991**

**Coastal Regulation Zone Notification** puts regulations on various activities, including construction, are regulated. It gives some protection to the backwaters and estuaries.

## LEGISLATIONS FOR CONTROL OF AIR POLLUTION

**1948**

**Factories Act and Amendment in 1987** was the first to express concern for the working environment of the workers. The amendment of 1987 has sharpened its environmental focus and expanded its application to hazardous processes.

**1981**

**Air (Prevention and Control of Pollution) Act** provides for the control and abatement of air pollution. It entrusts the power of enforcing this act to the Central Pollution Control Board.

**1982**

**Air (Prevention and Control of Pollution) Rules** defines the procedures of the meetings of the Boards and the powers entrusted on them.

**1982**

**Atomic Energy Act** deals with the radioactive waste.

**1987**

**Air (Prevention and Control of Pollution) Amendment Act** empowers the central and state pollution boards to meet with grave emergencies of air pollution.

**1988**

**Motor Vehicles Act** states that all hazardous waste is to be properly packaged, labeled and transported.

# GLOSSARY

**Abiotic:** Nonliving

**Abatement:** Reduction (Reduction of pollution/emissions)

**Ablation:** Wastage and loss of ice and snow from the surface of an ice-sheet or glacier that is generated by melting and evaporation. It also refers to removal of rock debris by wind action.

**Absolute:** A chemical substance relatively free of impurities.

**Acclimatization:** The adaptation over time of a species to a marked change in the environment.

**Acetone ($CH_3.CO.CH_3$):** Dimethyl ketone, used as a solvent for fats, oils, waxes, resins, rubber, plastics, lacquers, varnishes, rubber cements and in manufacturing plastics, chloroform and many other chemicals.

**Acid rain:** The precipitation of dilute solutions of strong mineral acids, formed in the atmosphere by the reaction of various industrial pollutants (such as sulfur dioxide and nitrogen oxides) with naturally occurring oxygen and water vapor.

**Acid:** An inorganic or organic compound that dissociates in water to yield hydrogen or hydronium ions, it has a pH of less than 7.0, neutralizes bases or alkaline media; and turns litmus paper red.

**Activated carbon:** A highly adsorbent form of carbon used to remove odors and toxic substances from gaseous and aqueous emissions.

**Activated sludge:** An aerobic biological process for conversion of soluble organic matter to solid biomass, removable by gravity or filtration.

**Acute health effect:** Health effects that usually occur rapidly as a result of short-term exposures, and are of short duration. Some examples are irritation, corrosivity (tissue destruction), narcosis, and death.

**Acute lethality:** The death of animals immediately or within 14 days after a single dose of or exposure to a toxic substance.

**Acute toxicity:** Any poisonous effect produced by a single short-term exposure, that results in severe biological harm or death.

**Adaptation:** A change in structure, physiology or habit of an organism that produces better adjustment to its surroundings.

**Adsorbent:** A material, usually solid, capable of holding gases, liquids and/or suspended matter at its surface in exposed pores. Activated carbon is a common adsorbent used in water.

**Adsorption:** Adhesion of an extremely thin layer of molecules (as of gas, solids or liquids) to the surface of solid or liquids with which they are in contact.

**Advanced waste water treatment:** Any treatment of sewage that goes beyond the secondary or biological water treatment stage and includes the removal of nutrients such as phosphorus and nitrogen and a high percentage of suspended solids.

**Aeration tank:** A chamber used to inject air or oxygen into water.

**Aerobic digestion (sludge processing):** Biochemical decomposition of organic matter by organisms living or active only in the presence of oxygen, which results in the formation of mineral and simpler organic compounds.

**Aerobic organism:** An organism that thrive well in presence of oxygen.

**Aerobic treatment:** Process by which microbes decompose complex organic compounds in the presence of oxygen and use the liberated energy for reproduction and growth.

**Aerosol:** A suspension of liquid or solid particles in a gas, the particles often being in the colloidal size range. Fog and smoke are common examples of natural aerosols; fine sprays (perfumes, insecticides, inhalants, antiperspirants, paints, etc.) are man-made aerosols.



**Agricultural pollution:** The liquid and solid wastes from farming, including, runoff from pesticides, fertilizers, and feed-lots, erosion and dust from plowing, animal manure and carcasses, crop residues, and debris.

**Air pollutant:** Any substance in air which could, if in high enough concentration, harm man, other animals, vegetation, or material. Some of the major air pollutants are $SO_2$, NOx, CO, HCs, and SPM.

**Air pollution episode:** A period of abnormally high concentration of air pollutants, often due to low winds and temperature inversion that can cause illness and death.

**Air quality standards:** The level of pollutants prescribed by law that cannot be exceeded during a specified time in a defined area.

**Airborne particulates:** Total suspended particulate matter found in the atmosphere as solid particles or liquid droplets. Airborne particulates include windblown dust, particles carbon, lead, mercury.

**Algal blooms:** Sudden spurts of algal growth, which can affect water quality adversely and indicate potentially hazardous changes in local water chemistry.

**Alkali:** Broadly, any compound having highly basic properties; i.e. one that readily ionizes in aqueous solution to yield OH anions, with a pH above 7, and turns litmus paper blue. Alkalies are oxides and hydroxides of certain metals and belong to group IA of the periodic table (Li, Na, K, Rb, Cs, Fr).

**Alkalinity:** Capacity of water to neutralize acids, a property imparted by the water's content of carbonates, bicarbonates, hydroxides, and, occasionally, borates, silicates and phosphates.

**Alpha particle:** A positively charged particle composed of 2 neutrons and 2 protons released by some atoms undergoing radioactive decay. The particle is identical to the nucleus of a helium atom.

**Ambient:** Surrounding conditions.

**Anadromous:** Fish that spend their adult life in the sea but swim upriver to fresh water spawning grounds to reproduce.

**Anaerobic:** Life or process that occurs in absence of oxygen, or not destroyed by, the absence of oxygen.

**Anoxia:** Lack of oxygen from inspired air (literally, "without oxygen").

**Antarctic "ozone hole":** Refers to the seasonal depletion of ozone in a large area over Antarctica

**Antidote:** A remedy to relieve, prevent, or counteract the effects of a poison. Eliminating the poison, neutralizing it, or absorbing it.

**Aquifer:** A porous, subsurface geological structure carrying or holding water; underground source of water.

**Asbestos:** A mineral fiber that can pollute air or water and cause cancer or asbestosis when inhaled.

**Asbestosis:** A disease associated with chronic exposure to and inhalation of asbestos fibers. The disease makes breathing progressively more difficult and can lead to death.

**Asphyxia:** Lack of oxygen and interference with the oxygenation of the blood. Can lead to unconsciousness.

**Asphyxiation:** A condition that causes asphyxia or suffocation. Asphyxiation is one of the principal potential hazardous of working in confined spaces.

**Asthma:** A disease characterized by recurrent attacks of dyspnea, wheezing, and perhaps coughing caused by spasmodic contraction of the main airways in the lungs.

**Atmosphere:** The whole mass of air surrounding the earth, composed largely of oxygen and nitrogen.

**Baghouse:** An air pollution abatement device used to trap particulates by filtering gas streams through large fabric bags usually made of glass fibers.

**Benthic region:** The bottom layer of a water body.

**Benthos:** The plants and animals that inhabit the bottom of a water body.

**Bequest values:** Willingness to pay to preserve the environment for the benefit of our children and grand children.



**Beryllium:** A metal that can be hazardous to human health when inhaled. It is discharged by machine shops, ceramic and propellant plants, and foundries.

**Beta particle:** An elementary particle emitted by radioactive decay that may cause skin burns. It is halted by a thin sheet of metal.

**Bioassay:** Using living organisms to measure the effect of a substance, factor, or condition.

**Biochemical oxygen demand (BOD):** Amount of oxygen in milligrams per liter used by microorganisms to consume biodegradable organics in wastewater under aerobic conditions. BOD(5) refers to the quantity of oxygen used by bacteria in consuming organic matter in a sample of wastewater over a five-day period.

**Bioconcentration:** The build-up of a chemical in plants and animals to levels above what is found in the surroundings.

**Biodegradable:** Any substance that decomposes quickly through the action of microorganisms.

**Biological control:** Using means other than chemicals to control pests, such as predatory organisms, sterilization, or inhibiting hormones.

**Biological magnification:** The concentration of certain substances up a food chain. A very important mechanism in concentrating pesticides and heavy metals in organisms such as fish.

**Biomass:** The amount of living matter in a given unit of the environment.

**Biomonitoring:** The use of living organisms to test water quality at a discharge site or downstream.

**Bioremediation:** Process using enzymatic actions of microbes or organisms to degrade and remove contaminants.

**Biosphere:** The portion of Earth and its atmosphere that supports life.

**Biota:** All living organisms of a region or system.

**Bog:** Wet, spongy land usually poorly drained, highly acid and rich in plant residue; characterizes eutrophication of water body.

**British thermal unit (BTU):** The quantity of heat required to raise the temperature of 1 lb of $H_2O$ from 63 degrees F to 64 degrees F.

**Buffer zone:** Refers to an area adjacent to a restricted zone, to which personnel may enter, but for which protective measures are recommended to minimize exposure to hazardous materials.

**Bulk density:** The measured density/volume ratio for a solid including or not corrected for the voids contained in the bulk of material, in kg/cubic meter.

**Cancer (carcinoma):** A malignant tumor or cancer; a new growth made up of cells that tend to grow rapidly, infiltrate other cells, and give rise to metastasis (spreading).

**Capital:** The existing stock of productive resources, such as machines and buildings, that have been produced.

**Capitalist economies:** Economies which use market-determined prices to guide peoples choices about the production and distribution of goods; these economies generally have productive resource which are privately owned.

**Carbon tax:** A charge on fossil fuels (coal, oil, natural gas) based on their carbon content. When burned, the carbon in these fuels becomes carbon dioxide in the atmosphere, the chief greenhouse gas.

**Carcinogen:** Agent that either causes cancer in humans, or, animals.

**Catalytic converter:** An air pollution abatement device that removes organic contaminants by oxidizing them into carbon dioxide and water.

**Chlorofluorocarbons (CFCs):** Stable, artificially-created chemical compounds containing carbon, chlorine, fluorine and sometimes hydrogen. Chlorofluorocarbons, used primarily to facilitate cooling in refrigerators and air conditioners, have been found to damage the stratospheric ozone layer which protects the earth and its inhabitants from excessive ultraviolet radiation.

**Chlorosis:** Discoloration of normally green plant parts that can be caused by disease, lack of nutrients, or various air pollutants.



**Chronic health effect:** An adverse effect on a human or animal body with symptoms that develop slowly over a long period of time or that recur frequently.

**Chronic toxicity:** The capacity of a substance to cause long-term poisonous human health effects.

**Clean fuel:** Fuels which have lower emissions than conventional petroleum products Refers to alternative fuels as well as to reformulated petrol and diesel.

**Climate change:** A regional change in temperature and weather patterns. Research indicates a discernible link between climate change and various anthropogenic activities, specifically the burning of fossil fuels.

**Closed economy:** An economy that neither exports nor imports.

**Coliform bacteria:** Bacteria found in the intestinal tract of warm-blooded animals and used as indicators of pollution if found in water. Coliform index- a rating of the purity of water based on a count of fecal bacteria.

**Common property resources:** Resources for which there are no clearly defined property rights; property owned in common by a society.

**Compact fluorescent:** Flourescent light bulbs small enough to fit into standard light sockets, which are much more energy-efficient than standard incandescent bulbs.

**Compost:** A mixture of naturally decomposed organic wastes, including food wastes, paper, and yard wastes. It is rich in minerals and ideal for gardening and farming as a soil conditioners, mulch, resurfacing material, or landfill cover.

**Conservation:** The protection, improvement, and use of natural resources according to principles that will assure their highest economic or social benefits.

**Consumer surplus:** The difference between what a person would be willing to pay and what he actually has to pay to buy a certain amount of a good.

**Contamination:** Intrusion of undesirable elements. The addition of foreign matter to a substance which reduces the value of the substance, or interferes with its intended use.

**Contingent valuation method:** A valuation method based on directly asking people what they are willing to pay for a benefit and/or willing to receive in compensation for tolerating a cost through a survey or questionnaire. It is subject to a number of biases that make it imprecise. The most serious of these is hypothetical bias.

**Cost-Benefit analysis:** A tally/comparison of expenditures and advantages in monetary terms resulting from various actions.

**Cost-Effectiveness analysis:** Least expensive way of achieving a given environmental quality target, or the way of achieving the greatest improvement in some environmental target for a given expenditure of resources.

**Damage function:** Relationship that shows how pollution damage varies with the level of pollution emitted, and what the monetary value of that damage is.

**Decibel (dB):** A unit for measurement of sound intensity. In general, a sound doubles in loudness for every increase of ten decibels.

**Defoliant:** A herbicide that removes leaves from trees and growing plants.

**Demand curve:** A graphic representation of the relationship between prices and the corresponding quantities demanded per time period. the relationship between quantity demanded of a good and the price, whether for an individual or for the market (all individuals) as a whole.

**Demographic effects:** Effects that arise from changes in characteristics of the population such as age, birthrates, and location.

**Deregulation:** The lifting of government regulations to allow the market to function more freely.

**Desulfurization:** Removal of sulfur from fossil fuels to cut pollution.

**Dioxin:** A man-made chemical by-product formed during the manufacturing of other chemicals and during incineration. Dioxin is one of the most potent animal carcinogen, as well as the cause of severe weight loss, liver problems, kidney problems, birth defects, and death.



**Dissolved oxygen (DO):** The oxygen freely available in water. The level of DO is considered an important indicator of quality of a water body.

**Dissolved solids:** The total of disintegrated organic and inorganic material contained in water. Excesses can make water unfit to drink or use in industrial processes.

**DNA:** Deoxyribonucleic acid, the molecule in which the genetic information for most living cells is encoded.

**E. coli:** *Escherichia coli*, one of the members of the coliform group of bacteria indicating fecal contamination.

**EC50:** Effective concentration 50. The concentration of a material in water, a single dose of which is expected to cause a biological effect on 50% of a group of test animals.

**ED50:** Effective dose 50. The calculated dose, derived experimentally, which would produce a specified effect in 50 percent of the test population.

**Effluent fee:** A fixed tax rate per unit (litre or kilogram) of emissions. It is also referred to as emission charge or emission tax.

**Environmental impact assessment:** An analysis, required legally to be carried out to assess the possible environmental impacts of a development project.

**Electrical conductivity:** Property which allows an electric current to flow when a potential difference is applied. It is the reciprocal of the resistance in ohms measured between opposite faces of a centimeter cube of an aqueous solution at a specified temperature. It is expressed as microohms per centimeter at temperature degrees Celsius.

**Electrostatic precipitator (ESP):** An air pollution control device that removes particles from a gas stream (smoke) after combustion occurs. The ESP imparts an electrical charge to the particles, causing them to adhere to metal plates inside the precipitator. Rapping on the plates causes the particles to fall into a hopper for disposal.

**Emission:** Pollution discharged into the atmosphere from smoke-stacks, other vents, and surface areas of commercial or industrial facilities; from residential chimneys; and from motor vehicle, locomotive, or aircraft exhausts.

**Endangered species:** Animal and plant species, or other living organisms threatened with extinction by man-made or natural changes in their environment.

**Eutrophication:** The slow aging process of a lake due to enrichment of nutrients either naturally or as a result of anthropogenic activities (organic pollution). During eutrophication the lake is choked by abundant plants which after death and decay lead to deficiency of dissolved oxygen. As a result all other aquatic life disappears.

**Existence value:** Value assigned to environmental goods for sheer existence, but not in utilitarian sense. For example, the sheer presence of the Royal Bengal Tiger has a non-use value for the humanity as a whole, as for many other endangered species, animals, birds, plants and so on.

**Fecal coliform bacteria:** A group of organisms found in the intestinal tracts of people and animals. Their presence in water indicates pollution and possible dangerous bacterial contamination.

**Fen:** A type of wetland that accumulates peat deposits. Fens are less acidic than bogs, deriving most of their water from groundwater rich in calcium and magnesium.

**Fluorosis:** An abnormal condition caused by excessive intake of fluorine, characterized chiefly by mottling of the teeth.

**Gamma ray:** The most penetrating waves of radiant nuclear energy. They can be stopped by dense materials like lead.

**Greenhouse effect:** The warming of our atmosphere caused by buildup of carbon dioxide, methane etc. which allows light from the Sun's rays to heat the Earth but prevents loss of the heat.

**Gross National Product (GNP):** The total market value, in terms of money, of all final goods and services produced in a country in one year.

**Groundwater:** The supply of fresh water found beneath the Earth's surface, usually in aquifers, which is often used for supplying wells and springs.

**Habitat:** An identifiable region in which a particular kind of organism lives; The sum of environmental conditions in a specific place that is occupied by an organism, population or community.



**Half-Life:** The time taken by certain materials to lose half their amount or strength. For example, the half life of DDT is 15 years and of radium 1,580 years; The time required for half of the atoms of a radioactive element to undergo decay.

**Hardness:** A characteristic of water, imparted by salts of calcium, magnesium and iron, such as bicarbonates, carbonates, sulfates, chlorides and nitrates, that cause curdling of soap, deposition of scale, damage in some industrial processes and sometimes objectionable taste.

**Hazardous waste:** Any solid, liquid or combination of solid or liquid wastes, which, because of its physical, chemical or infectious characteristics, may pose a hazard when improperly managed; Substances that could endanger life if released into the environment.

**Heavy metals:** Metals which can be precipitated by hydrogen sulfide in acid solution, e.g., lead, silver, gold, mercury, bismuth, copper, nickel, iron, chromium, zinc, cadmium and tin.

**Hedonic pricing approach:** Derives values by decomposing market prices into components encompassing environmental and other characteristics through studying property values, wages and other phenomena. The premise of the approach is that the value of an asset depend on the stream of benefits derived, including environmental amenities.

**Herbivores:** Primary consumers; animals that eat plants.

**Heterotrophic organism:** Consumers such as humans and animals, and decomposers chiefly bacteria and fungi — that are dependent on organic matter for food.

**Horizon:** A horizontal layer in the soil. The top layer (A horizon) has organic matter. The lower layer (B horizon) receives nutrients by leaching. The C horizon is partially weathered parent material.

**Humus:** Decomposed organic material in soil.

**Hydrocarbons (HC):** Group of organic compounds consisting of carbon and hydrogen atoms that are evaporated from

fuel supplies or are remnants of the fuel that did not burn completely, and that act as a primary air pollutant.

**Hydrogeology:** The geology of ground water, with particular emphasis on the chemistry and movement of water.

**Hydrologic cycle:** The water cycle, including precipitation of water from the atmosphere as rain or snow, flow of water over or through the earth and evaporation or transpiration to water vapor in the atmosphere.

**Hydrology:** The science dealing with the properties, distribution, and circulation of water.

**Hydroxyl ion ($OH^-$):** A negatively charged particle consisting of a hydrogen and an oxygen atom, commonly released from materials that are alkaline in nature.

**Hypothetical bias:** Difference in actual willingness to pay and willingness to pay revealed in a survey arising from the fact that in actual markets purchasers suffer real costs, while in surveys they do not.

***In situ*:** In the original situation.

**Incinerator:** A controlled chamber where waste substances are burnt.

**Indicator:** An organism, species, or community that shows the presence of certain environmental conditions.

**Indoor air pollution:** Chemical, physical, or biological contaminants in indoor air (the breathing air inside a habitable structure or conveyance).

**Industrial wastes:** Liquid or solid wastes generated through industrial processes. It is distinct from domestic or sanitary wastes in terms of its composition.

**Infiltration:** The penetration of water through the ground surface into sub-surface soil or the penetration of water from the soil into sewer or other pipes through defective joints, connections, or manhole walls.

**Insecticide:** A pesticide specifically designed to kill or control insects.

**Integrated pest management:** Combining the best of all useful techniques — biological, chemical, cultural, physical, and mechanical — into a custom-made pest control system.



**Intrinsic Values:** Value that resides 'in' something and that is unrelated to human beings altogether.

**Iron bacteria:** Microscopic organisms which are capable of using ferrous iron, either from the water or from steel pipe, in their metabolism and precipitating ferric hydroxide in their sheaths and gelatinous deposits. *Thiobacillus ferrooxidans* is generally regarded as the principal iron-oxidizing bacterium

**Isotope:** Atoms of the same element that have different numbers of neutrons.

**Landfills:** Landfills are land disposal sites for non-hazardous solid wastes at which the waste is spread in layers, compacted to the smallest practical volume, and cover material applied at the end of each operating day.

**Law of demand:** People purchase more of any particular good or service as its relative price falls; they purchase less as its relative price rises.

**Law of supply:** At higher relative prices, the quantity supplied of a good will increase; at lower relative prices, smaller quantities will be supplied.

**LD 50/lethal dose:** The dose of a toxicant that kills 50 percent of the test organisms within a designated period of time. The lower the LD 50, the more toxic the compound.

**Leachate:** Materials that pollute water as it seeps through solid waste.

**Leaching:** The downward movement of minerals from the A horizon to the B horizon by the downward movement of soil water.

**Lead:** A heavy metal that is hazardous to health if breathed or swallowed.

**Lime:** A common water treatment chemical. Limestone, $CaCO_3$, is burned to produce quicklime, CaO, which is mixed with water to produce slaked, or hydrated, lime.

**Limestone scrubbing:** Process in which sulfur gases moving towards a smokestack are passed through a limestone and water solution to remove sulfur before it reaches the atmosphere.

**Limiting factor:** A condition, whose absence, or excessive concentration, is incompatible with the needs or tolerance of a species or population and which may have a negative influence on their ability to grow or even survive; The one primary condition of the environment that determines the success of an organism.

**Limnology:** The study of the physical, chemical, meteorological, and biological aspects of fresh water.

**Littoral zone:** Region with rooted vegetation in a freshwater ecosystem.

**Macroeconomics:** The study of the sum total of economic activity, dealing with the issues of growth, inflation and unemployment and with national economic policies relating to these issues.

**Macronutrient:** A nutrient, such as nitrogen, phosphorus, and potassium, that is required by plants in relatively large amounts.

**Malthusian trap:** The minimum subsistence level to which humans descend as a result of geometric population growth and arithmetic resource growth.

**Market economy:** A decentralized system where many buyers and sellers interact.

**Market:** A network in which buyers and sellers interact to exchange goods and services for money.

**Mercury:** A heavy metal, highly toxic if breathed or swallowed.

**Microeconomics:** The study of the individual parts of the economy, the household and the firm, how prices are determined and how prices determine the production, distribution and use of goods and services.

**Micronutrient:** A nutrient needed in extremely small amounts for proper plant growth; examples are boron, zinc, and magnesium.

**Mobile source:** A moving producer of air pollution, mainly forms of transportation — cars, motorcycles, planes.

**Monitoring:** Periodic or continuous sampling to determine the level of pollution or radioactivity.

**Monitoring wells:** Wells drilled at a hazardous waste management facility to collect ground-water samples for the purpose of physical, chemical, or biological analysis to determine the amounts, types, and distribution of contaminants in the ground water beneath the site.



**Natural resources:** Structures and processes that can be used by humans for their own purposes, but cannot be created by them. They include land, fish, wildlife, biota, air, water, ground water, drinking water supplies, and other such resources.

**Nausea:** A tendency to vomit; a feeling of sickness in the stomach.

**Niche:** The total role an organism plays in a habitat.

**Nitrate:** A compound containing nitrogen which can exist in the atmosphere or as a dissolved gas in water and which can have harmful effects on humans and animals. Nitrates in water can cause severe illness in infants.

**Nitric oxide (NO):** A gas formed by combustion under high temperature and high pressure in an internal combustion engine. It changes into nitrogen dioxide in the ambient air and contributes to photochemical smog.

**Nitrogen dioxide ($NO_2$):** Nitric oxide combining with oxygen in the atmosphere forms nitrogen dioxide which is a major component of photochemical smog.

**Nitrogen oxide (NOx):** Refers to various oxides of nitrogen, e.g., NO, $NO_2$.

**Nitrogenous wastes:** Animal or plant residues that contain large amounts of nitrogen.

**Noise:** Any undesired sound.

**Nonpersistent pollutants:** Those pollutants that do not remain in the environment for long periods and are biodegradable.

**Nonpoint source:** Pollution sources which are diffuse and do not have a single point of origin or are not introduced into a receiving stream from a specific outlet. Common non-point sources are: agriculture, forestry, urban, mining, construction, dams and channels, land disposal, and saltwater intrusion.

**Nonrenewable energy sources:** Those energy sources that are not replaced by natural processes, or those whose rate of replacement is so slow as to be noneffective.

**Nontarget organism:** An organism whose elimination is not the purpose of pesticide application.

**Nuclear winter:** Prediction by some scientists that smoke and debris rising from massive fires resulting from a nuclear war could enter the atmosphere and block out sunlight for weeks or months. The scientists making this prediction project a cooling of the earth's surface, and changes in climate which could, for example, negatively effect world agricultural and weather patterns.

**Nutrients:** Elements or compounds essential to growth and development of living things; carbon, oxygen, nitrogen, potassium and phosphorus.

**Oligotrophic lakes:** Deep, cold, nutrient-poor lakes that are low in productivity.

**Open dump:** Specifically, any facility or site where solid waste is disposed of in open.

**Opportunity cost:** The highest-valued sacrifice needed to get a good or service.

**Option value:** Potential benefits of the environment not derived from actual use. This expresses the preference or willingness to pay for the preservation of an environment against some probability that the individual will make use of it at some later date.

**Organophosphates:** Pesticides that contain phosphorus, used to control insects. They are short-lived and work by interfering with normal nerve impulses of the organism.

**Overburden:** The layer of soil and rock that covers deposits of desirable minerals. It is cleared away before mining

**Oxides of nitrogen (NO and $NO_2$):** Primary air pollutants consisting of a variety of different compounds containing nitrogen and oxygen.

**Ozone ($O_3$):** Ozone is a form of oxygen found naturally which provides a protective layer shielding the earth from ultraviolet radiation's harmful health effects on humans and the environment. Found in two layers of the atmosphere, the stratosphere and the troposphere.

**Ozone depletion:** Destruction of the stratospheric ozone layer which shields the earth from ultraviolet radiation harmful to biological life.



**Particulates:** Small pieces of solid materials, such as smoke particles from fires, bits of asbestos from brake linings and insulation, dust particles, or ash from industrial plants, that are dispersed into the atmosphere.

**Peat:** The first stage in the conversion of organic material into coal.

**Pelagic:** Those organisms that swim in open water.

**Periphyton:** Attached organisms in freshwater streams and rivers, including algae, animals, and fungi.

**Permafrost:** Permanently frozen ground.

**Peroxyacetyl nitrate (PAN):** A secondary pollutant created by the action of sunlight on hydrocarbons and nitrogen oxides in the air.

**Persistent pesticide:** A pesticide that remains unchanged for a long period of time as it does not break down chemically in the environment after a growing season.

**Persistent pollutant:** A pollutant that remains in the environment for many years in an unchanged condition.

**pH:** The negative logarithm of the hydrogen ion concentration. A unit for measuring hydrogen ion concentrations. A pH of 7 indicates a "neutral" water or solution. At pH lower than 7, a solution is acidic. At pH higher than 7, a solution is alkaline.

**Photochemical oxidants:** Air pollutants formed by the action of sunlight on oxides of nitrogen and hydrocarbons.

**Photochemical smog:** A yellowish-brown haze that is the result of the interaction of hydrocarbons, oxides of nitrogen, and sunlight.

**Phytoplankton:** Free-floating, microscopic, chlorophyll-containing organisms.

**Point source:** Any discernible, confined, and discrete conveyance from which pollutants are or may be discharged.

**Pollutant:** A contaminant at a concentration high enough to endanger the environment and life therein.

**Pollution costs:** The private or public expenditures undertaken to avoid pollution damage once pollution has occurred and the increased health costs and loss of the use of public resources because of pollution.

**Pollution fee or tax:** Charge for the amount of waste or pollution. Several European nations have air and water pollution charges; Unit pricing for trash pickup, charging by the amount of trash collected (or the size of the container). The charge makes it worthwhile for a producer to cut back, right up to the point where it begins to cost more to reduce pollution than to pay the tax.

**Pollution:** Any undesirable change in physical, chemical and biological characteristics of Environment or its component that may adversely affect the life and property.

**Polychlorinated biphenyl (PCB):** A pathogenic and teratogenic industrial compound used as a heat-transfer agent.

**Population:** A group of interbreeding organisms of the same kind occupying a particular space. The number of humans or other living creatures in a designated area.

**Potable water:** Water that is safe for drinking and used for cooking.

**Present value:** Value today of a sum to be paid or collected in the future to buy a good or service.

**Price:** The amount of money, or other goods, that you have to give up to buy a good or service.

**Primary consumer:** An organism that eats plants (producers) directly.

**Primary pollutants:** Chemicals released directly into the environment in a harmful form. Sulfur dioxide, oxides of nitrogen, carbon monoxide etc. are some of the primary air pollutants.

**Primary sewage treatment:** The first stage of waste water treatment; which removes larger particles by filtering raw sewage through large screens.

**Primary succession:** Succession that begins with bare mineral surfaces or water.

**Producer:** An organism that can manufacture food from inorganic compounds and light energy.

**Property rights:** The conditions of ownership of an asset, the rights to own, use and sell. The right to use or consume something, or trade the right away in return for something else.



**Public goods:** Goods that cannot be withheld from people even if they don't pay for them. A good which, if made available to one person, automatically becomes available to all others in the same amount.

**Radioactive half-life:** The time it takes for half of the radioactive material to spontaneously decompose.

**Radioactive:** Unstable nuclei that release particles and energy as they disintegrate.

**Receiving waters:** Any water body where untreated wastes are dumped.

**Recycling:** The process of reclaiming a resource and reusing it for another or the same structure or purpose.

**Reforestation:** The process of replanting areas after the original trees were removed.

**Regulation:** The legal mechanism that spells out how a statute's broad policy directives are to be carried out.

**Rem:** A measure of the biological damage to tissue caused by certain amounts of radiation.

**Renewable energy sources:** Those energy sources that can be regenerated by natural processes. Sun, wind, water, biomass are some of the renewable energy sources.

**Reserves:** The known deposits from which materials can be extracted profitably with existing technology under present economic conditions.

**Resource exploitation:** The use of natural resources by society.

**Riparian habitat:** Areas adjacent to rivers and streams that have a high density, diversity, and productivity of plant and animal species relative to nearby uplands.

**Run-off:** Water from rain, snow melt, or irrigation that flows over the ground surface and returns to streams. It can collect pollutants from air or land and carry them to the receiving waters.

**Scrubber:** An air pollution control device that uses a spray of water to trap pollutants and cool emissions.

**Secondary sewage treatment:** Biochemical treatment of waste-water after the primary stage, using bacteria to consume the organic wastes. Use of the activated sludge

process removes floating and settleable oxygen demanding substances.

**Sedimentation tanks:** Holding areas for waste water where floating wastes are skimmed off and settled solids are pumped out for disposal.

**Seepage:** Water that flows through the soil and rocks.

**Silicosis:** A condition of massive fibrosis of the lungs causing shortness of breath because of prolonged inhalation of silica dust.

**Silt:** Fine particles of soil or rock that can be picked up by air or water and deposited as sediment.

**Sludge:** Any solid, semi-solid, or liquid waste generated from a municipal, commercial, or industrial wastewater treatment plant, water supply treatment plant, or air pollution control facility exclusive of the treated effluent from a wastewater treatment plant.

**Soft water:** Any water that is not "hard", i.e., does not contain a significant amount of dissolved minerals such as salts containing calcium or magnesium.

**Soot:** Fine particles, usually black, formed by combustion (complete or incomplete) and consisting chiefly of carbon. Soot gives smoke its color.

**Species:** A reproductively isolated aggregate of interbreeding populations of organisms.

**Surface water:** The water naturally open to the atmosphere (rivers, lakes, reservoirs, streams, impoundments, seas, estuaries, etc.).

**Sustainable development:** A principle which states that a development plan must not compromise the welfare of future generations for the benefit of present generations.

**Tailings:** Residue of raw materials or waste separated out during the processing of mineral ores.

**Teratogen:** Substance that causes malformation or serious deviation from normal development of embryos and foetuses.

**Tertiary sewage treatment:** Advanced cleaning of waste water that goes beyond the secondary or biological stage. It



removes nutrients such as phosphorus and nitrogen and most suspended solids.

**Thermal pollution:** Discharge of heated water from industrial processes that can affect the life processes of aquatic plants and animals.

**Tolerance:** The ability of an organism to cope with changes in its environment. Also the safe level of any chemical applied to crops that will be used as food or feed.

**Topography:** The physical features of a surface area including relative elevations and the position of natural and manmade features.

**Total dissolved solids (TDS):** Total amount of dissolved solid materials present in an aqueous solution.

**Total suspended solids (TSS):** Solids found suspended in wastewater or in the stream, which in most cases can be removed by filtration.

**Toxic substances:** Any chemical or material that has evidence of an acute or chronic health hazard.

**Toxicology:** The study of the nature, effects, and detection of poisons in living organisms. Also, substances that are otherwise harmless but prove toxic under particular conditions.

**Travel cost method:** Derives values by evaluating expenditures of recreators. Travel costs are used as a proxy for price in deriving demand curves for the recreation site.

**Turbidity:** A condition in water or wastewater caused by the presence of suspended matter resulting in the scattering and adsorption of light rays.

**Uranium:** A radioactive heavy metal element used in nuclear reactors and the production of nuclear weapons. U 238 and U 235 are naturally occurring isotopes of uranium.

**User benefits/User values:** Benefits or value derived from the actual use of the environment. Anglers, hunters, boaters, nature walkers, bird watchers, etc. use the environment and derive benefits.

**Volatile organic compound (VOC):** Volatile organic compound; family of highly evaporative organic materials

used in a variety of industrial applications, such as paints and solvents; VOC emissions are a component in the formation of ground-level ozone (smog).

**Waste-water:** Any water that has been released from the purpose for which it was intended to be used.

**Water table:** The level of ground water.

**Watershed:** The land area that drains into a stream.

**Wetlands:** An area that is regularly saturated by surface or ground water and subsequently is characterized by a prevalence of vegetation that is adapted for life in saturated soil conditions. Examples include: swamps, bogs, fens, marshes, and estuaries.

**Xenobiotic:** Term for non-naturally occurring man-made substances found in the environment (i.e., synthetic solvents, plastics).

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# OTHER BOOKS OF INTEREST


## Development and Environment

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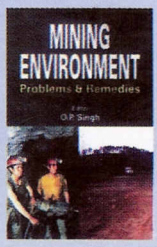


## Mining Environment

### Problems and Remedies

*O.P. Singh* (ed.)

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