DJN3E - ENVIRONMENTAL ECONOMICS

Unit - I Definitions and role of Environmental Economics

Economics and environment – Scope and significance of Environmental Economics, Integration of conservation and development

Unit - II The Environment and Economy

Relationship between the environment and the economic system – the material balance model – Environment as a resource – Service of the environment – Limited assimilative capacity of the environment – Environmental quality.

Unit - III Conservation of Resources

Definition and Meaning Conservation water, conservation of wild life, conservation of forests, soil conservation, energy conservation. Methods of conservation – Material substitution – Product life extension – Recycling conditions for successful Recycling – Optimum recycling – Waste reduction.

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Nature and sources of pollution in India – AIR pollution, water pollution, soil pollution, Marine pollution, India's Environmental Policy - Efforts of the Government to control pollution and environmental protection. National Committee on Environmental planning and Co-ordination (NCEPC), Tiwri Committee (11980) – Department of Environment (DOE) Pollution Control Board (PCB)

Books for Reference:

1. Environmental Economics: - Dr. P. Sankaran
2. Environmental Economics - Varadarajan and S. Elangoven
3. Environmental Economics - Kneese, Allen V.
4. Environmental Economics - Seneeca J.J. and H.K. Taussig

UNIT I

DEFINITIONS AND ROLE OF ENVIRONMENTAL ECONOMICS

1.1. INTRODUCTION

Environmental Economics deals with the application of economic principles to the solution of local and global environmental problems. In the early phase of environmental revolution, the economists had very little role to play in policy decisions. The federal environmental policy in U.S. and many other countries were based on command and control regulation type. The simply enacted laws and non-compliance led to penalty and punishment. Slowly, the economic issues were brought to focus; the main reason being the cost involved in the earliest policy. The potential use of economic instruments started receiving attention in many environmental measures in U.S and OECD countries in late 80's. The UN conference on Environmental and Development an International Forum held in 1991, popularly known as Rio Summit, MoEF, GoI issued policy statement which deliberated on how to make effective use of economic instruments to combat environmental problems. Economic instruments influence the decision of the individual or polluter through incentives and as a result it gives the flexibility to the polluter to use his or her best information to select cost effective methods (Tietenberg, 1990).

Problems are mounting in areas such as urban population, industrial pollution, atmospheric emission, soil erosion and land degradation, deforestation and irreversible loss of biodiversity due to increasing human pressure on natural resources. The underlying cause of environmental degradation in countries like India is failure of market and institutions, a factor which has not been adequately focused on corrective actions.

Environmental economics is an emerging area in the realm of economic science. Before 1970s a little attention was paid for the growth and development of this part of the area of knowledge in economics. The first oil stock in 1971 and thereafter the emergence of relatively higher levels of environmental damages at the global level prompted the scholars in this field to apply economic tools to environmental science. Studies on environmental science are plentifully available, however they do not cover the economic content of environment. Similarly, early economists of the classical and neoclassical regime made specific comments about the significance of nature and environment, but

did not include them in their exposition of theories. Today, people all over the world have realised that environment is not just the study of flora and fauna, but a synthesis of study of various branches of knowledge like Science, Economics, Philosophy, Ethics, Anthropology, etc. Therefore, a study of environmental economics calls for a detailed understanding about various environmental factors, their influence in the economy, their functions upon the environment, and their impacts upon the life of the people of the present and future.

1.2 MEANING OF ENVIRONMENTAL ECONOMICS

According to Arun Balasubramanian, "no longer is economics merely a science of production and distribution, it has to take into account the ecological repercussions of economic activities that could affect both production and distribution." It means that economics as a subject cannot exist in isolation, it cannot even be a mere study of how goods and services are produced, but at the same time it has to take into consideration the impacts of the use of resources on the environment. The impacts may be in the form of externality, pollution, exhaustion, etc. Any study on the economic content of production, distribution, development, etc., cannot be completed without touching upon the environmental aspects like externality, pollution, damage, exhaustion, depletion etc. Environmental economics can therefore be defined as that "part of economics which deals with interrelationship between environment and economic development and studies the ways and means by which the former is not impaired nor the latter impeded." It is thus a branch of economics which discusses about the impacts of interaction between men and nature and finds human solutions to maintain harmony between men and nature. Environmental economics teaches us how to promote economic growth of nations with least environmental damage. Classical and neoclassical school of thoughts underestimated the environmental issues of production and consumption, since they considered these issues merely as social issues. When the environmental goods get transferred into economic goods, the problems of environmental damage crop up, and therefore the need to interact with economic principles.

1.3 ECONOMY AND THE ENVIRONMENT—INTERLINKAGES

Man cannot exist in isolation. Man's life is interconnected with various other living and non-living things. His life also depends on social, political, economic, ethical, philosophical and other aspects of social system. In fact, the life of human beings is shaped by his living environment. What exactly is living environment? Environment means "all the conditions, circumstances, and influences surrounding and affecting the development of an organism or group of organisms". It also means that the complex of physical, chemical and biotic factors that act upon an organism or an ecological community and ultimately determine its form and survival.

Environment, environmentalists, environmentalism etc., are the common words used in our ordinary life in recent years. Environmentalists are those who love and care for environment, who realize that any damage to the environment will affect the life of living things. Environmental concern of environmentalists and fundamental environmentalists are different. The former upholds and tries to popularize the need for environmental education. But the latter embraces environment in its virgin form and any intervention in the ecological balance of the environment mars the very survival of living things. Therefore, fundamental environmentalists are always treated as anti-developmentalists. But the works of such persons are always appreciated by the people at large.

The words Ecology and Economics stem from the same Greek root 'Oikos' which means habitation. Ecology is the study of the relationship or interdependence between living organisms and their environment. Hence in Greek root, Ecology deals with the 'household and nature', while Economics deal with the 'household of man'. An ecological balance exists in the society in which all the living things live harmoniously. But the problem is that man in his aspiration for better living has upset the ecological balance thereby endangering nature as well as himself.

Quite often we find that there is a conflict between 'Economy' and 'Ecology'. Ecology studies harmony between nature and man, whereas Economics spells out the disharmony between man and nature. The disharmony arises as a result of the incompatibility of the basic ecological principle of stability as a precondition for the sustainability of ecological system and the economic principles of business profitability.

To restore harmony, to reconcile the interests of human beings and nature—an ecological reorientation of the economic policy is required. Environmental studies would help to create this awareness among the people.

The relationship between the economy and the environment is generally explained in the form of a "Material Balance Models" developed by Alen Kneese and R.V. Ayres. The material balance models are based on the first and second law of Thermodynamics. These models consider the total economic process as a physically balanced flow between inputs and outputs. Inputs are bestowed with physical property of energy which is received from the sun. The resulting output from input carries the same level of energy. Similar to this, there are wastes resulting from consumption activities. Materials and energy are drawn from the environment, which are used for production and consumption activities and returned to environment as wastes. So far as this balance is maintained, there are no environmental issues. The material balance model of the economy is given in the Figure 1.1.

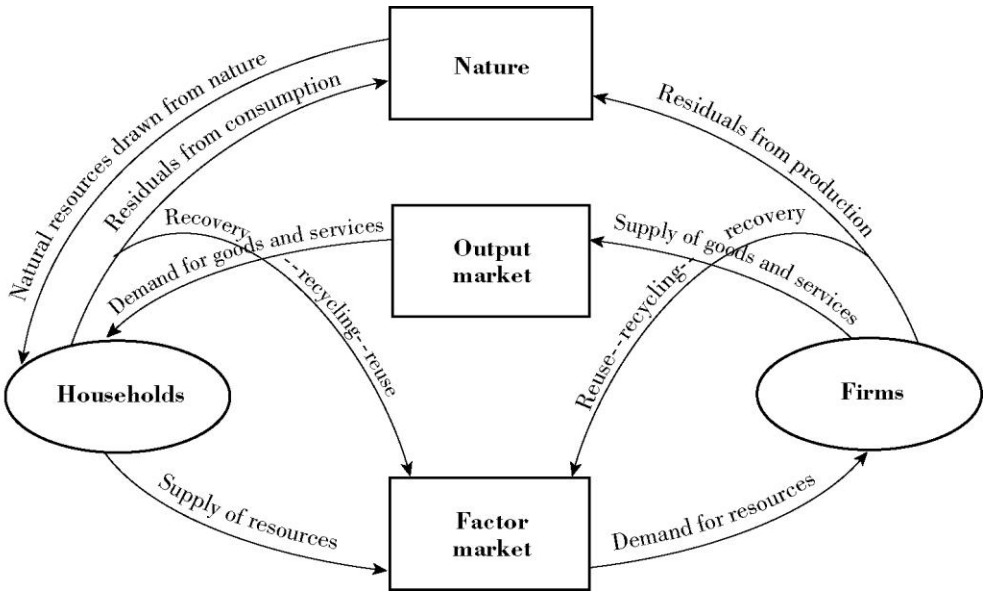


Fig: 1.1 The material balance model: interdependence of economics and environment

The Figure 1.1 shows that environment is the supplier of all forms of resources like renewable and non-renewable, and it is also acting as a sink for cleaning up of wastes. Households and firms are connected to environment, and they are interconnected

too. Households and firms depend on nature for resources. Both households and firms send out residuals of consumption and production respectively to nature. As mentioned earlier nature has the power to assimilate all forms of waste. But this power is conditional. So long as earth is not being disturbed by the excess amount of wastes, the earth can clean up natural wastes. When the earth fails to respond to 3 Rs, the symptoms of environmental damage appears. Thus, there is a rhythm in the use and reuse of resources for men by men; Earth cannot respond properly to man-made or artificial wastes. Man-made wastes are piling up around us, and therefore, the extent of damage to the environment has been on the rise. All the wastes that are being sent out cannot be cleaned up by the sink earth. As long as earth can discharge this function of cleaning up of pollution due to wastes, there would not be any environmental issue. But earth has reached at the saturation point of this process, and it is helpless in cleaning up of several types of wastes resulting in major environmental issues in the world over.

The impact of the transformation of material inputs and energy into output is subject to several changes in the biosphere. The process of transformation is better explained with the help of the laws of thermodynamics. The first two laws of thermodynamics are worth mentioning in this context. The first law of thermodynamics, which is often referred to as the law of conservation of matter and energy says that energy, like matter, can neither be created nor destroyed, but at the same time the forms of energy can be transformed. The law stresses that the total amount of energy created through production and consumption activities must be equal to the total sum of initial energy extracted from nature. Therefore, the first law of thermodynamics implies the accounting identities of material balance model. The second law of thermodynamics is known as the law of entropy. Entropy is usually considered as the measure of unavailability of the benefits of energy or simply wastes. When one form of energy is transformed into another (say for example, when the thermal energy of coal is converted into electrical energy) there is waste of energy, and the volume of waste depends upon the technological process. Entropy will be low, when materials and energy are highly structured and organised. When a piece of coal is kept idle, there is low entropy, but when it is burnt up, the same piece of coal is subject to high entropy, since heat and carbon dioxide are dissipated, but sometimes unavailable for use. Thus, the second law

says that as long as there is utilisation of material inputs and energy for production and consumption activities, the level of entropy will be high. Economic activity helps to convert low entropy resources and energy into high entropy wastes *i.e.,* resources into wastes. Economic activities cannot be stopped on account of high entropy, but at the same time, through recycling and waste management, it is possible to bring into the economic system, low entropy value. Use of natural resources, but at the same time with minimal waste or damage to the environment is considered as the key theme of sustainable development. It is a form of development path that is ready to meet the needs (not greed) of the present generation, at the same time without compromising the needs of posterity. A detailed discussion of sustainable development is included as a separate chapter in this book.

We must know that the environment discharges the following economic functions:

1. The environment is the supplier of all forms of resources.
2. The wastes are cleaned up by the environment.
3. The environment maintains genetic diversity and stabilizes the ecosystem.7

The above mentioned functions of the environment are interlinked. In the name of economic activity the environmental resources are transformed into economic goods [converting low entropy resources into high entropy ones]. In this process of transformation, wastes are created. Resources are also getting depleted due to the overuse. When environment is disturbed by the overuse and the huge amount of wastes, it cannot discharge the third function *i.e.,* maintaining genetic diversity and stabilization of ecosystems. It further affects the life and existence of flora and fauna. Therefore an integrated approach to the study of economy, ecology, and environment is essential, as all these are closely interlinked.

1.4 DIFFERENCE BETWEEN ENVIRONMENTAL ECONOMICS AND RESOURCE ECONOMICS

Prior to 1980s little attention was paid to the study of environmental economics. Instead, the theory that was being popularised among the social scientists was known as Resource Economics. Until the early 1950s natural resource supply and conservation had been neglected by modern economists. Orris C. Herfindahl8 was the first to go beyond descriptive survey and to view mineral resources as economic goods. Therefore resource economics was concerned with the production and use of natural and mineral resources of both renewable and non-renewable character. The pollution aspect of resource use was not a concern of resource economists. They traced resource economics as flows with dynamic factors. Environmental economics is concerned with the impact of economic activities on the environment, the significance of ecosystem to the economy, and suggests the appropriate ways of regulating economic activity, so that cosmic balance is achieved in the society. Resource economics does not bother about the environmental impact of production and consumption, but environmental economics deals with these aspects. Environmental economists point out the "right volume of pollution" which the society can bear. In order to attain this 'balanced' level of production and pollution, economists recommended economic tools like market mechanism principles. This is so because, in the case of environment, market fails to bring equilibrium. Market fails because environment is a public good. But by assigning true values to the environmental goods it is possible to apply market mechanism principles. These aspects are covered in environmental economics which distinguishes it from resource economics.

1.5 ENVIRONMENT AND ETHICS

Environment and ethics are two separate branches in human knowledge. Environment is the complex of physical, chemical and biotic factors that act upon an ecological community. Ethics on the other hand is a branch of knowledge which explains what is good and bad, and with moral duty and explanations. Stanford Encyclopaedia of Philosophy considers environmental ethics as the discipline that studies the moral relationship of human beings to and also the value and moral status of environment and its nonhuman contents. An ethical aspect of environment seems to have attained higher priority in recent years. Neglect of environmental ethics means neglecting the true or the

intrinsic value of environment. Environment is not exclusively for homosapiens. Other innumerable species depend on environment for food and procreation. These points need to be followed by any student of environment or environmental economics. Thus under the branch of environmental economics, we may pose the following questions.

These are known as the ethical questions of environment.

1. Does the earth exist for the benefit of humanity?
2. Do humans have any ethical obligation towards other living species?
3. Do we have the right to take all the earth's resources for our own use?
4. Do we have the right to kill all other species for human needs?
5. Do other species have an intrinsic right to exist?
6. How do religions view humanity's relationship with the rest of living things?

These and other questions are addressed in the study of environmental ethics. Ethics of environment is seemed to have been isolated from the analysis of economic theories by the classical and neoclassical writers. Classicists believed that production of wealth would bring prosperity to individuals and society. But the ethical aspect of production was not clearly verified. For example, production of arms and ammunitions contribute wealth, but is it the real wealth of the society? The craze of allotting huge amount of money for defence purpose by majority of the nations has been condemned by the philanthropists and environmentalists on the ground that such activity is against the ethical spirit of the society. Similarly in the name of development we destroy our environmental goods. The real benefit of development (sustainable development) is that it should listen to the ethical and environmental aspects of development. Ethical aspects of environment are the basic instinct of environmental protection and conservation. If the economy as a whole is not able to imbibe the true spirit of the ethics of environment, the impact and the dimensions of environmental damages would be very high.

1.6 ENVIRONMENTAL ECONOMICS AND ENVIRONMENTAL POLICY

Concern with the environment is brought on in large part by the coincidence of high income and high population density. If there were a few people in the world, earth's environment would be capable of absorbing most of the wastes that they throw at it. The demand for environmental quality is income elastic. This is one of the reasons for higher levels of environmental damage, and this is quite dominant in developing economies. The

higher income groups treat environment as luxury good. For the marginalised groups and the poverty stricken, environment is a perennial source of food and shelter. For them environmental concern is in their blood, and therefore they generally do not disturb the environment. But as the main concern of these groups of people is to earn food, they put environmental issues in the back seat. The poor are the worst suffers of environmental damage. There is an unacceptable theory being popularised in the Third World countries by the rich that the poor are the creators of environmental damage, because higher levels of population is found in these economies. As a reply to this argument, the leaders of the Third World countries point out that the environment of these countries are being damaged by the overuse of resources in order to meet the requirements of the rich West. It is found that there exists a positive correlation between income and the demand for environmental quality. Higher demand for environmental quality will result in higher levels of environmental damages. It means that as income (Y) increases, damages to the environment also increase. However this theory is not found suitable to developed economics. In such countries, higher levels of income promote higher levels of environmental protection. But this argument need not be true always.

When the rich nations grow substantially, they depend on other developing nations for resources. In such dependent economics, there will be higher levels of environmental damages. The relationship between income and environmental quality (Environmental damages too) is represented in Figure 1.2. The figure shows that when the income of the people increases from OY to OY1 and then to OY2, the demand for environmental quality increases from OQ to OQ1 and then to OQ2, correspondingly. In fact there exists a positive correlation between income and environmental quality. Income and environmental damages are also positively correlated. Students of environmental economics now think what role environmental economics can play to minimise the environmental damages.

1. There are a few methods by which economics can interfere.
2. Assign environmental costs to resources under use.
3. Use price as a tool to avoid waste of resources.
4. Allocation of environmental resources based on true costs and real benefits.
5. Resource conservation through environmental management.

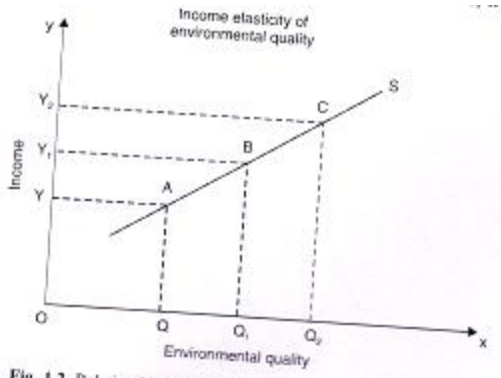


Fig. 1.2. Relationship between income and environmental quality

The above methods are basically economic in nature. However, due to internal and external factors, or socio-political reasons, the nations are constrained to accommodate economic principles in valuing resources. Environmental economics plays a crucial role in assigning true costs to scarce resources, as well as popularisation of environmental management. From the above discussion one is able to realise that separate environmental policies are required to address these critical issues. Therefore, suitable environmental policies applicable to each nation, and also at the same time to address transnational environmental issues are to be formulated. For example, in India, there are several environmental laws passed by both States and Union Governments. It means that to solve environmental issues that cropped up off and on, and also to avert the local or regional environmental threats that are likely to take place, a suitable environmental policy is essential. Each State government and the Central Government should declare their environmental policies from time to time so that the level and extent of environmental destruction can be minimised through laws. The environmental policies of India, Europe, and the USA differ in several respects.

1.7 SCOPE AND SIGNIFICANCE OF ENVIRONMENTAL ECONOMICS

SCOPE

The role of environmental economists is inevitable in policy design and implementation for achieving sustainable development. . Essentially, environmental economics revolves around three broad questions.

1. What are the economic and institutional causes of environmental problems? That is, how do economic and social systems shape incentives in ways that lead to environmental degradation as well as to improvements?
2. How can we assess the economic importance (ie monetary value) of environmental degradation/improvements?
3. How can we design economic incentives to slow or halt environmental degradation and bring about improvements in the quality of the natural environment?

The first question leads to an analysis of market failure and government failure.

For example, one of the principal reasons for market failure is that there are incomplete markets in environmental assets. There are plenty of examples of where markets are incomplete including:

1. Clean air
2. Beautiful views
3. Unpolluted beaches
4. Tropical rainforests, with their biodiversity and their carbon-fixing properties
5. A quiet environment

To ensure that we employ scarce resources efficiently the environment needs to be included in economic calculations, and environmental economics aims to do this.

The second question requires that we are able to place economic values on environmental degradation/improvements. As we have already noted, many environmental resources and goods are not priced in markets. Thus, to do this environmental economics has developed a set of methods to place values on these types of goods.

The third question is the main focus of this module. We will use economic tools critically to evaluate environmental policies, and whether they are likely to achieve the aim of decreasing or halting environmental degradation

Valuation is an issue in environmental management because for many natural goods and environmental services there are no markets either because property rights are not clearly defined or there exists a high transaction cost for creating and operating the markets. For instance, forest resources provide non-market uses such as protection

against flooding and erosion, biodiversity and aesthetic values which have no markets. Economists have developed various methods by which the non-marketed values can be estimated. Cropper and Oates (1992) made a survey of various valuation methods for environmental goods and services.

1.8 SIGNIFICANCE

The relationship between Environment and Economics is not only very close, but also very vast and numerous that the entire discipline of „Environmental Economics" becomes multidimensional and holistic in nature. It is mainly the interaction between welfare aspect of the society and growth theories of economics. It covers almost all branches between economics of growth and welfare economics.

1.8.1 ECONOMIC GROWTH AND ENVIRONMENTAL BALANCE: Economics of growth is mainly interested in the „economics Welfare" of the society and not „general welfare" as the latter is a very wide, elusive and also complicated concept. General Welfare" as the latter is a very wide, elusive and also complicated concept. General welfare of the society covers a very wide range of economics and non-economic factors.

According to Paretian concept, social welfare is the collective of all individuals in the society. Even if one individual is better off, without anyone being worse off, the social welfare is said to have been increased. Welfare economists have attempted to associate welfare economics with ethics. According to them, under no circumstances can economics be kept separate from ethics. Samuelson, Berg son and others have pointed out that economics and ethics must go hand and value judgments cannot be avoided in welfare economics. Economics ends where ethics fails. Growth economics concentrates its theories mainly on economics welfare which is measured in terms of high rates of growth of per capita product rise in productivity, high rate of structural transformation, urbanization, international flows of men, goods and capital etc. Countries measure their growth by means of Gross National Product (GNP) in terms of millions of dollars in a year. There is little place for ethics in growth economics. Ethics does not come into the picture of taking decisions between butter and bombs; chocolates or cigarettes; wheat or whisky. As long as, the commodities are demanded by consumers and wheat or available, they are produced, irrespective of the fact, whether it is socially desirable or not. In the process of over-utilisation of resources in the growth process, the ecosystem gets strained

and consequently the sustainability of the ecosystem and the maintainability of economic growth get impaired and impeded. These two incompatible components of cost-benefit analysis have to be compromised, which becomes the basic fabric of the study of environmental economics. Ethics and social welfare have larger role to play in the integration of the economics of welfare and economics of growth. So, the first theoretical dimension of Environmental Economics is the study of implications of welfare Economics in environmental concepts. It is, in short, the study of Economics Growth versus Environmental Balance. It is the study of finding out the golden mean between the two.

1.8.2 ECONOMICS OF RESOURCE USE: Environment is the repository of resources for the development of mankind. All resources come from Nature. I.e. productions of goods are possible only with the help of resources supplied by Nature. Food, clothing or shelter or any other commodities and services can be provided only with the help of resources supplied by Nature (Environment) in the form of elements. The earth gives minerals like iron, manganese, zinc, aluminum, silver, gold, coal, petroleum, etc. The entire agricultural activities depend on soil, irrigation, humidity which is the results of natural gifts. Industrial production is impossible without the materials supplied by Nature. Even the production of so called synthetic materials is possible only with the elements and chemicals supplied by nature. In short, out living on this earth is possible only the resources supplied by environment. These resources have becomes an important component of the study of environmental Economics. Optimum use of resources and conservation of resources have become important issues in modern planning for

1.8.3 POLLUTION CONTROL AND ENVIRONMENT: The next component of the study of Environmental Economics is the cost of pollution control and its implications on the environment. Production and growth result in pollution, which is an externality in the process of production, deterring the efficient functioning of the market forces. Hence, the starting point of environmental economics is the theory of externality, pollution and other similar matters, causing deviation from the welfare maximizing principle. Thus apart from being a starting point, it becomes the special branch of welfare economics.

1.9 INTEGRATION OF CONSERVATION AND DEVELOPMENT

We have a dream – a world without poverty – a world that is equitable – a world that respects human rights – a world with increased and improved ethical behavior regarding poverty and natural resources - a world that is environmentally, socially and economically sustainable, and where economic growth is accomplished within the constraints of realising social objectives of poverty eradication and social equity and within the constraints of nature's life support carrying capacity, and a world where the challenges such as climate change, loss of biodiversity and social inequity have been successfully addressed. This is an achievable dream, but the system is broken and our current pathway will not realise it.

Unfortunately, humanity‘s behavior remains utterly inappropriate for dealing with the potentially lethal fallout from a combination of increasingly rapid technological evolution matched with very slow ethical-social evolution. The human ability to do has vastly outstripped the ability to understand. As a result civilization is faced with a perfect storm of problems driven by overpopulation, overconsumption by the rich, the use of environmentally malign technologies, and gross inequalities. They include loss of the biodiversity that runs human life support systems, climate disruption, global toxification, alteration of critical biogeochemical cycles, increasing probability of vast epidemics, and the specter of a civilization-destroying nuclear war. These biophysical problems are interacting tightly with human governance systems, institutions, and civil societies that are now inadequate to deal with them.

The rapidly deteriorating biophysical situation is more than bad enough, but it is barely recognized by a global society infected by the irrational belief that physical economies can grow forever and disregarding the facts that the rich in developed and developing countries get richer and the poor are left behind. And the perpetual growth myth is enthusiastically embraced by politicians and economists as an excuse to avoid tough decisions facing humanity. This myth promotes the impossible idea that indiscriminate economic growth is the cure for all the world's problems, while it is actually (as currently practiced) the disease that is at the root cause of our unsustainable global practices.

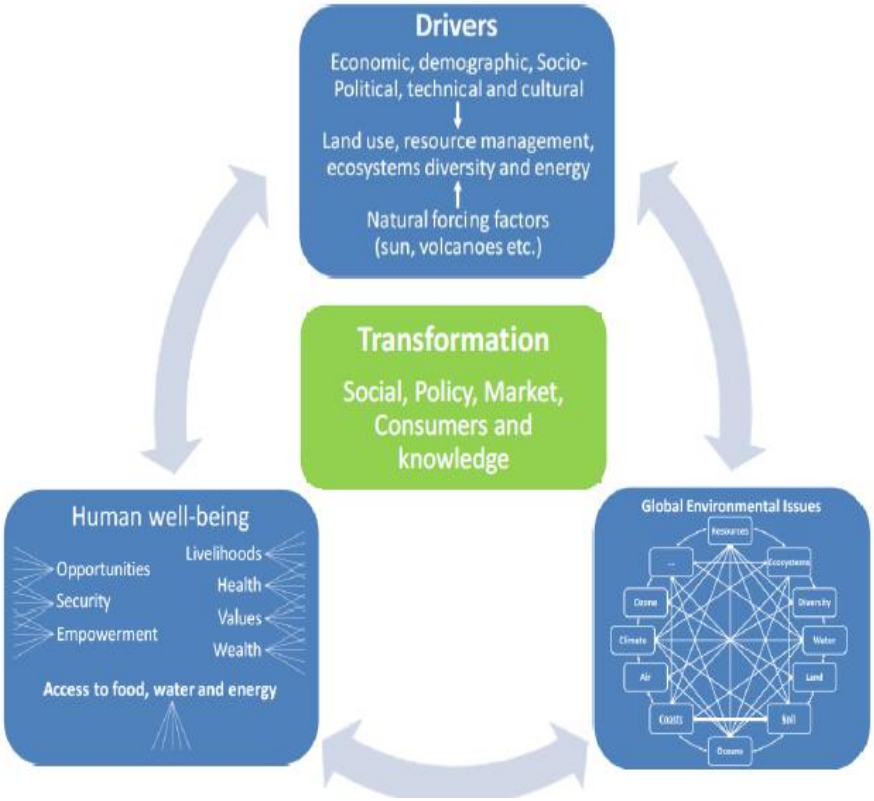
In the face of an absolutely unprecedented emergency, society has no choice but to take dramatic action to avert a collapse of civilization. Either we will change our ways and build an entirely new kind of global society, or they will be changed for us.

In order to realise our dream of a more sustainable world there is a need to understand the triple interdependence of economic, social and environmental factors and integrate them into decision-making in governments and the private sector. One challenge facing many countries is how to manage natural resources in order to contribute to poverty alleviation while maintaining the ecological life support system. In economics the main issue deals with what, where and how much of the natural resources are required to alleviate poverty, while social issues deal with for whom and how much are resources developed, and environmental issues address how natural resources can be managed with minimum negative impact on ecosystems. The interaction between economic, social and environment are enhanced and its coordination made more effective if their respective goals are translated into quantitative terms within a defined time scale. What is needed is to realize economic growth within the constraints of social and environmental sustainability.

1.10 UNDERLYING DRIVERS OF CHANGE

The major indirect drivers of change are primarily demographic, economic, socio-political, technological, cultural and religious (Figure 1). These affect climate change and biodiversity loss somewhat differently, although the number of people and their ability to purchase and consume energy and natural resources are common to both issues. Human-induced climate change is primarily driven by the aggregate consumption and choice of technologies to produce and use energy, which is influenced by energy subsidies and unaccounted costs, hence the current over-reliance on burning fossil fuels. The loss of biodiversity and the degradation of ecosystems and their services are primarily due to the conversion of natural habitats, overexploitation of resources, air, land and water pollution, introduction of exotic species and human-induced climate change.

FIGURE 1



1.10.1 DEMOGRAPHIC

The global population, which has now passed 7 billion people, and the average per capita energy consumption have both increased sevenfold over the past 150 years, for an overall fiftyfold increase in the emissions of carbon dioxide into the atmosphere. And both are still increasing. As a global average, total fertility rates (TFR) are decreasing, as a result of more females completing primary and secondary education, along with availability of fertility control. But this global average conceals many local difficulties. In some parts of the world fertility remains high and decline in these countries is by no means certain. More than 200 million women in developing countries still have unmet needs for family planning, and increased investment in reproductive health care and family planning programmes along with education programmes will be critical. Although the desire and the need are increasing, it is estimated that funding globally decreased by

30% between 1995 and 2008, not least as a result of legislative pressure from the religious right in the USA and elsewhere.

The ageing of populations in many countries around the world is also a relevant sustainable development issue. The economic, social and environmental implications are as yet unclear but his trend will undoubtedly have an impact. Whether it is positive or negative depends to a large extent on how countries prepare e.g., in evaluating what an ageing population will mean for economic productivity, consumption of goods and services, and in terms of urban planning, financial, health and social care systems etc.

Both culturally and genetically, human beings have always been small-group animals, evolved to deal with at most a few hundred other individuals. Humanity is suddenly, in ecological time, faced with an emergency requiring that it quickly design and implement a governance and economic system that is both more equitable and suitable for a global population of billions of people, and sustainable on a finite planet.

1.10.2 ECONOMICS

Uncontrolled economic growth is unsustainable on a finite planet. Governments should recognise the serious limitations of GDP as a measure of economic growth and complement it with measures of the five forms of capital, built (produced), financial, natural, human and social capital: i.e., a measure of wealth that integrates economic, social and environmental dimensions and is a better method for determining a country‘s productive potential.

The failure of the economic system to internalize externalities leads to the continuation of environmentally damaging activities. If externalities are uncorrected then markets fail: they generate prices that do not reflect the true cost to society of our economic activities. Emissions of greenhouse gases represent a market failure as the damages caused by emissions from the burning of fossil fuels are not reflected in prices. The price of fossil fuels should reflect the true cost to society, resulting in a more level playing field for environmentally-sound renewable energy technologies and a stimulus to conserve energy. There are a range of economic instruments for correcting the emissions market failure from taxes and emissions trading schemes, to standards and other regulations. All are likely to be needed.

There are a number of other relevant market failures that must also be corrected if we are to manage the risks of climate change: correcting the emissions externality on its own will not be sufficient. For example, there are market failures around research and development (innovation), there are imperfections in capital markets that prevent financing for low-carbon infrastructure, there are network externalities, e.g. around electricity grids and public transport, there are failures in the provision of information, and there are failures in valuing ecosystems and biodiversity. In addition, environmentally-damaging subsidies in areas such as energy, transportation and agriculture, which total about $1 trillion per year, cause further market distortion and are in general leading to environmental degradation and should be eliminated. We must act strongly across all these dimensions.

Correcting the biodiversity and ecosystem market failure is particularly urgent and important. The benefits that we derive from the natural world (biodiversity and ecosystem services) and its constituent ecosystems are critically important to human well-being and economic prosperity, but are consistently undervalued in economic analysis and decision making. Contemporary economic and participatory techniques allow us to take into account the monetary and non-monetary values of a wide range of ecosystem services. These techniques need to be adopted in everyday decision-making practice. Failure to include the valuation of non-market values in decision making results in a less efficient resource allocation, with negative consequences for social well-being. Recognising the value of ecosystem services would allow the world to move towards a more sustainable future, in which the benefits of ecosystem services are better realised and more equitably distributed.

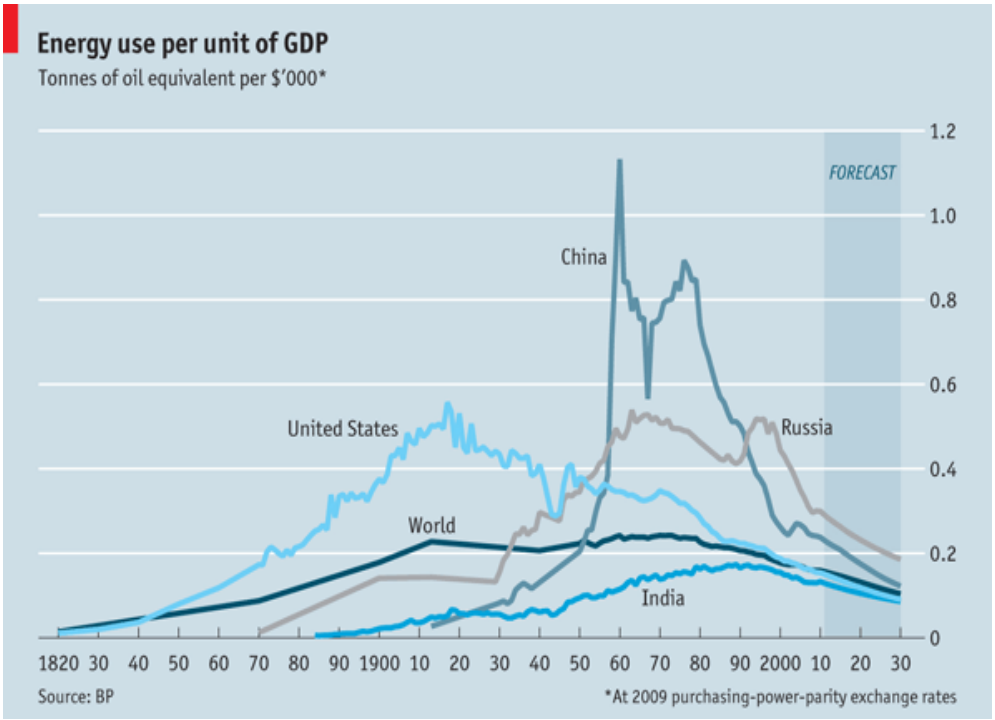
Correcting these market failures is also important if developing countries are to continue to advance and improve their living standards. The economic emergence of the BRICS (Brazil, Russia, India, China, and South Africa) over recent decades has been a major success story. Their combined share of world GDP has increased from 23% to 32% over the last six decades. In contrast, over the same period the OECD share of world GDP has declined from 57% to 41%. This rapid economic growth has seen great improvements in health, literacy, and income. However, this rapid growth and development was achieved mostly through the increased use of fossil fuels (which in

2008 represented 90% of their energy consumption) and through the unsustainable exploitation of natural resources including oceans and forests. As a consequence

1.10.3 TECHNOLOGY

The over-reliance on fossil fuel energy (coal, oil and gas) and inefficient end-use technologies has significantly increased the atmospheric concentrations of carbon dioxide and other greenhouse gases. We are currently putting one million years worth of sequestered carbon into the atmosphere each year. Recent efforts to reduce the carbon intensity (CO2/GDP) were made in a large number of countries, particularly in China and Russia where the carbon content has declined significantly in the last 30 years albeit from very high levels (Fig-1.4). However the carbon intensities of India, South Africa and Brazil (including deforestation) have not declined significantly in that period. It is therefore clear that all countries have to take serious measures to reduce their CO2 emissions in the next few decades, recognizing the principle of differentiated responsibilities. OECD countries alone, despite their efforts to reduce their carbon intensity (and carbon emissions), will not be able to avoid the world‘s growth of carbon emissions.

Fig 1.4



1.10.4 SOCIO-POLITICAL

There are serious shortcomings in the decision making systems on which we rely in government, business and society. This is true at local, national and global levels. The rules and institutions for decision making are influenced by vested interests, yet each interest has very different access to how decisions are made. Effective change in governance demands action at many levels to establish transparent means for holding those in power to account. Governance failures also occur because decisions are being made in sectoral compartments, with environmental, social and economic dimensions addressed by separate, competing structures. The shift of many countries, and in particular the United States, towards corporate plutocracies, with wealth (and thus power) transferred in large quantities from the poor and middle-classes to the very rich, is clearly doing enormous environmental damage. The successful campaign of many of the fossil fuel companies to downplay the threat of climate disruption in order to maintain the profits of their industry is a prominent example.

1.10.5 CULTURAL

The importance to reducing inequity in order to increase the chances of solving the human predicament is obvious just in the differences in access to food and other resources caused by the giant power gap between the rich and the poor. The central geopolitical role of oil continues unabated despite the dangerous conflicts oil-seeking already has generated and the probable catastrophic consequences its continued burning portends for the climate.

1.11 INTEGRATION OF ENVIRONMENTAL, ECONOMIC AND SOCIAL SUSTAINABILITY

The Earth's environment is changing on all scales from local to global, in large measure due to human activities. The stratospheric ozone layer has been damaged, the climate is warming at a rate faster than at any time during the last 10,000 years, biodiversity is being lost at an unprecedented rate, fisheries are in decline in most of the world‘s oceans, air pollution is an increasing problem in and around many major cities, large numbers of people live in water stressed or water scarce areas, and large areas of land are being degraded. Much of this environmental degradation is due to the

unsustainable production and use of energy, water and food and other biological resources, and is already undermining efforts to alleviate poverty and stimulate sustainable development, and worse, the future projected changes in the environment are likely to have even more severe consequences.

1.12 CLIMATE CHANGE

There is no doubt that the composition of the atmosphere and the Earth‘s climate have changed since the industrial revolution predominantly due to human activities, and it is inevitable that if those activities do not shift markedly, these changes will continue regionally and globally. The atmospheric concentration of carbon dioxide has increased by over 30% since the pre-industrial era primarily due to the combustion of fossil fuels and deforestation. Global mean surface temperature, which had been relatively stable for over 1000 years, has already increased by about 0.75oC since the pre-industrial era, and an additional 0.5oC to 1.0oC is inevitable due to past emissions. It is projected to increase by an additional 1.2-6.4oC between 2000 and 2100, with land areas warming significantly more than the oceans and Arctic warming more than the tropics.

Precipitation is likely to increase at high and middle latitudes and in the tropics, but likely to decrease in the subtropical continents. At the same time, evaporation increases at all latitudes. Over continents water is likely to be more plentiful in those regions of the world that are already water-rich, increasing the rate of river discharge and the frequency of floods. On the other hand water stress will increase in the sub-tropics and other water-poor regions and seasons that are already relatively dry, increasing the frequency of drought. Therefore, it is quite likely that global warming magnifies the existing contrast between the water-rich and water-poor regions of the world. Observations suggest that the frequencies of both floods and droughts have been increasing as predicted by the climate models.

The Earth‘s climate is projected to change at a faster rate than during the past century. This will likely adversely affect freshwater, food and fiber, natural ecosystems, coastal systems and low-lying areas, human health and social systems. The impacts of climate change are likely to be extensive and primarily negative, and to cut across many sectors. For example, throughout the world, biodiversity at the genetic, species and landscape level is being lost, and ecosystems and their services are being degraded.

Although climate change has been a relatively minor cause of the observed loss of biodiversity and degradation of ecosystems, it is projected to be a major threat in the coming decades.

There is a limit on the amount of fossil fuel carbon that we can pour into the atmosphere as carbon dioxide without guaranteeing climatic consequences for future generations and nature that are tragic and immoral. Given the decadal time scale required to phase out existing fossil fuel energy infrastructure in favor of carbon-neutral and carbon-negative energies, it is clear that we will soon pass the limit on carbon emissions. The inertia of the climate system, which delays full climate response to human-made changes of atmospheric composition, is simultaneously our friend and foe. The delay allows moderate overshoot of the sustainable carbon load but also brings the danger of passing a point of no return that sets in motion a series of catastrophic events. These could include melting of the Greenland and West Antarctic ice sheets leading to a sea level rise of many meters; melting of permafrost leading to significant emissions of methane, a potent greenhouse gas; and disruption of the ocean conveyor belt leading to significant regional climate changes. These impacts would largely be out of human control.

The risks from unmanaged climate change, as well as loss of biodiversity, are immense and action is urgent. Global warming due to human-induced increases in carbon dioxide is essentially irreversible on timescales of at least a thousand years, mainly due to the storage of heat in the ocean. Hence, decisions about anthropogenic carbon dioxide emissions being made today will determine the climate of the coming millennium. Even if emissions were to stop entirely in the 21st century, sea level would continue to rise. The level of carbon dioxide reached in this century will determine whether low lying areas are inundated by ice mass losses from Greenland and Antarctica, even if it occurs slowly over many centuries, because the warming will persist.

The world‘s current commitments to reduce emissions are consistent with at least a 3 degree C rise (50-50 chance) in temperature. Such a rise has not been seen on the planet for around 3 million years, much longer than *Homo sapiens* have existed. There is even a serious risk of a 5 degrees C increase, to an average temperature not seen on the planet for 30 million years. This is a problem for risk management and public action on a

great scale. The fundamental market failure is the unpriced ―externality‖ of the impact of emissions. Other crucial market failures exist including those associated with R&D and learning, networks/grids, information, and further market failures around co-benefits such as valuation of ecosystem services and biodiversity issues. Policy will fail to generate the scale and urgency of the response required if it considers only the emissions market failure. The global community‘s attempts to address climate change have been hopelessly inadequate.

The costs of climate change, already projected at 5% or more of global GDP, could one day exceed global economic output if action is not taken. The globe requires bold global leadership in governments, politics, business and civil society to implement the solutions, which have been scientifically demonstrated and supported by public awareness, to save humanity from climate change catastrophe.

1.13 BIODIVERSITY, ECOSYSTEMS AND THEIR SERVICES

Biodiversity – the variety of genes, populations, species, communities, ecosystems, and ecological processes that make up life on Earth – underpins ecosystem services, sustains humanity, is foundational to the resilience of life on Earth, and is integral to the fabric of all the world‘s cultures. Biodiversity provides a variety of ecosystem services that humankind relies on, including: provisioning (e.g. food, freshwater, wood and fiber, and fuel); regulating (e.g. of climate, flood, diseases); cultural (e.g. aesthetic, spiritual, educational, and recreational), and supporting (e.g. nutrient cycling, soil formation, and primary production). These ecosystem services contribute to human wellbeing, including our security, health, social relations, and freedom of choice and action, yet they are fragile and being diminished across the globe.

We are at risk of losing much of biodiversity and the benefits it provides humanity. As humankind‘s footprint has swelled, unsustainable use of land, ocean, and freshwater resources has produced extraordinary global changes, from increased habitat loss and invasive species to anthropogenic pollution and climate change. Threats to terrestrial and aquatic biodiversity are diverse, persistent, and, in some cases, increasing. The Millennium Ecosystem Assessment concluded that 15 of the 24 ecosystem services evaluated were in decline, 4 were improving, and 5 were improving in some regions of

the world and in decline in other regions. Action is critical: without it, current high rates of species loss are projected to continue what is becoming the 6th mass extinction event in Earth‘s history. It has been estimated that for every 1oC increase in global mean surface temperature, up to 5oC, 10% of species are threatened with extinction All species count, but some more than others at any given time and place. Losing one key species can have cascading effects on the delivery of ecosystem services.

Ecosystem services are ubiquitous, benefiting people in a variety of socioeconomic conditions, across virtually every economic sector, and over a range of spatial scales, now and in the future. The benefits that ecosystems contribute to human well-being have historically been provided free of charge, and demand for them is increasing. Although the global economic value of ecosystem services may be difficult to measure, it almost certainly rivals or exceeds aggregate global gross domestic product, and ecosystem benefits frequently outweigh costs of their conservation. Yet environmental benefits are seldom considered in conventional economic decision-making, and costs and benefits often don‘t accrue to the same community, or at the same time or place.

The value of these ecosystem services is being increasingly appreciated by a very large sector of society - extending from local stakeholders, the business community, agriculture, conservation, and governmental policy makers, including development agencies. Their economic value is enormous and a fundamental element of green economic development. However, we are degrading these services and squandering our natural capital for short-term gains. Two thirds of ecosystem services are currently being degraded globally, which will soon amount to an estimated loss of $500 billion annually in benefits. Green economic development will require technology development and technology transfer in order to increase value added from biological resources, especially in developing countries. This would help shift from the resource exploitative method of conventional development to the resource enrichment method of sustainable development.

1.14 FOOD SECURITY

Total food production has nearly trebled since 1960, per capita production has increased by 30%, and food prices and the percent of undernourished people have fallen,

but the benefits have been uneven and more than one billion people still go to bed hungry each night. Furthermore, intensive and extensive food production has caused significant environmental degradation. Aside from the loss of much biodiversity through outright habitat destruction from land clearing, tillage and irrigation methods can lead to salinisation and erosion of soils; fertilizers, rice production and livestock contribute to greenhouse gas emissions; unwise use of pesticides adds to global toxification; and fertilizer runoff plays havoc with freshwater and near shore saltwater habitats.

One of the key challenges facing the world is to increase agricultural productivity, while reducing its environmental footprint through sustainable intensification, given that the demand for food will likely double in the next 25 to 50 years, primarily in developing countries. Unfortunately, climate change is projected to significantly decrease agricultural productivity throughout much of the tropics and sub-tropics where hunger and poverty are endemic today.

The Right to Food should become a basic human right; a combination of political will, farmers‘skill and scientists‘commitment will be needed to achieve this goal.

1.15 WATER SECURITY

Projections show that by 2025 over half of the world‘s population will live in places that are subject to severe water stress, and by 2040 demand is projected to exceed supply. This is irrespective of climate change, which will likely exacerbate the situation. Water quality is declining in many parts of the world, and 50 to 60% of wetlands have been lost. Human induced climate change is projected to decrease water quality and availability in many arid- and semi-arid regions and increase the threats posed by floods and droughts in most parts of the world. This will have far-reaching implications, including for agriculture: 70% of all freshwater withdrawn from rivers and aquifers is currently used for irrigation. Of all irrigation water use 15 to 35% of irrigation water use already exceeds supply and is thus unsustainable.

Freshwater availability is spatially variable and scarce, particularly in many regions of Africa and Asia. Numerous dry regions, including many of the world‘s major ―Food bowls, will likely become much drier even under medium levels of climate change. Glacier melt, which provides water for many developing countries, will likely decrease over time and exacerbate problems of water shortage over the long term. Runoff

will decrease in many places due to increased evapo-transpiration. In contrast, more precipitation is likely to fall in many of the world‘s wetter regions. Developed regions and countries will also be affected. For example, Southern Europe in summer is likely to be hotter and drier.

1.16 HUMAN SECURITY

Climate change and loss of ecosystem services, coupled with other stresses threatens human security in many parts of the world, potentially increasing the risk of conflict and in-country and out-of-country migration (Fig-1.5).

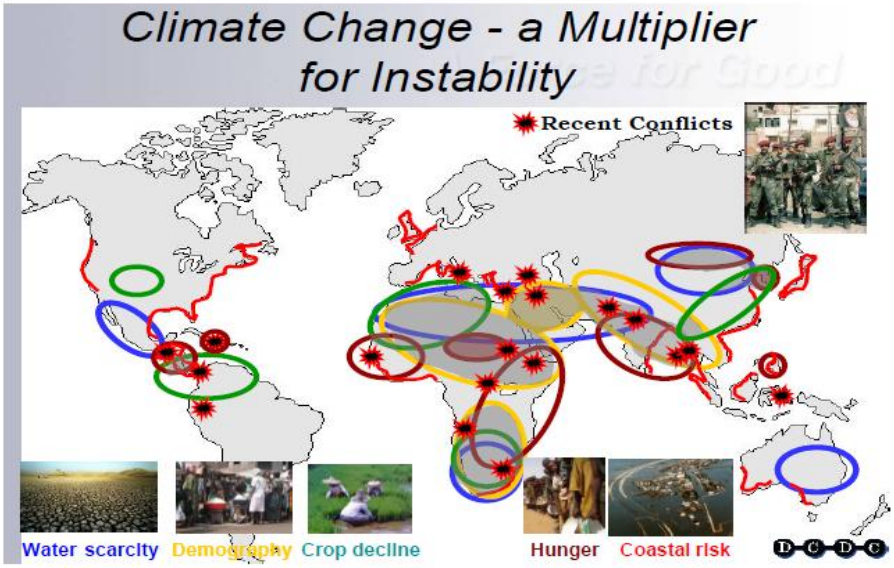


Fig: 1.5

Climate change risks the spread of conflict by undermining the essentials of life for many poor people: (i) food shortages could increase where there is hunger and famine today; (ii) water shortages could become severe in areas where there are already water shortages; (iii) natural resources could be depleted with loss of ecological goods and services; (iv) tens of millions of people could be displaced in low-lying deltaic areas and Small Island States; (v) disease could increase; and (vi) severe weather events could be become more frequent or intense.

Many countries in sub-Saharan Africa have millions of people in abject poverty (per-capita incomes of less than $1 per day), lack access to adequate food, clean water and modern energy sources, and are particularly dependent on natural resources for their

very existence. In some cases governments lack good governance and are faced with political instability, with some in conflict and others merging from conflict. Hence, climate change, coupled with other stresses, risks local and regional conflict and migration depending on the social, economic and political circumstances.

Unit-II

ENVIRONMENT AND ECONOMY

2.1 Introduction

The natural environment is an important component of the economic system, and without the natural environment the economic system will not be able to function. Hence, in recent years economists have started treating the natural environment in the same way as they treat labor and capital as an asset and a resource. According to environmental economists, environmental degradation is the result of the failure of the market system to put the deserving value on the environment, even though the environment serves economic functions and provides economic and other benefits. It is argued that, because environmental assets are free or under-priced, they tend to be overused and abused, resulting in environmental damage. The solution offered to the above problem is to put a price on the environment so that it can be incorporated into the economic system and taken seriously by those who make decisions. However one of the major problems in putting a price on the environment is that it is highly objected by many as it is similar to putting a price tag on your family and friendship. Another problem with valuing the environment is that the preferences of future generations and other species are not taken into account Economy and environment interaction.

It is a general belief that we can't have both economic development and environmental quality simultaneously, that if we want to improve economically we must sacrifice the environment. Often in the past Economic Development has been given importance over the environment and society. There is a mutual connection between environment and economy that is often not recognized. There is a widely held theory that resource management practices and policies which protect the environment are most likely to harm the economy and reduce employment opportunities. However, empirical data supporting this theory are rare. In recent years, economists and ecologists have increasingly begun to use quantitative methods to test this theory. Studies examining industrial emissions, endangered species, air quality and other issues have found no evidence that economies suffer as environmental policy strength increases. On the contrary, numerous researchers have reported slight positive correlations between environmental and economic indices, suggesting that environmental health may help to improve the economy. Methods are being

developed to measure the value of clean water and air, and healthy forests throughout the world. Estimated values vary widely, but studies agree that clean, rivers, clean air, biodiversity, and open space are highly valued by the public and that the public is willing to pay to preserve and enjoy these resources.

For example, properties near clean rivers have been found to be worth more than similar properties elsewhere. Another rapidly expanding field of study is the valuation of "ecosystem services". Ecosystem services are the processes by which the environment produces resources that we often take for granted such as clean water, timber, and habitat for fisheries, and pollination of native and agricultural plants. The following is list of the positive impacts of environmental protection on a nation's economy.

1. Environmental protection prevents pollution and the related cost of health care.
2. Reduction in pollution results in increased yield from agriculture and cattle.
3. A healthy environment supports healthy human beings and increases productivity.
4. In a protected environment, the effects of natural calamities such as drought and flood will be less.
5. Environmental protection produces job opportunities in the field of green industries and ecotourism.
6. As policymakers begin to incorporate environmental conservation into resource management laws and practices, the quality and sustainability of our lives and economies will improve.

2.2 Environmental economics

Environmental economics is a branch of economics concerned with environmental issues. Environmental Economics involves theoretical and empirical studies of the economic effects of national or local environmental policies around the world. Particular issues in environmental economics include the costs and benefits of alternative environmental policies to deal with air and water pollution, toxic substances, solid waste, and global warming. Thus environmental economics addresses environmental problems and valuation of nonmarket environmental services. In general, environmental economics focuses on efficient allocation and accepts the assumption of neoclassical economics that the economic system is the whole and not a subsystem of the global ecosystem.

2.3 Economics of development

The standard measure of economic progress around the world is the Gross Domestic Product (GDP). GDP may be defined as the total market value of all final goods and services produced in a country in a given year, equal to total consumer, investment and government spending, plus the value of exports, minus the value of imports. GDP accounts for the money value of all exchanges of goods and services, regardless of their social or environmental value. The costs of oil spills, crime, traffic accidents, and cancer operations all are accounted in the GDP. There are other alternative indices, which account for social and environmental costs and benefits and more accurately track whether we are really happy as a result of economic growth. Such indices show a decline in recent decades. For example, the Index of Sustainable Economic Welfare (ISEW) paralleled the GDP until about 1966. Since then the GDP has continued upwards, but the ISEW stayed constant.

2.4 Preservation and Conservation

The terms preservation and conservation are often confused, but there is a difference between them. Preservation implies complete protection, and leaving the natural resources totally untouched. Conservation implies the management of resources on a sustainable yield basis. Preservation is the process of protecting an environment without any alterations or human intervention. It is a necessary tool in certain cases. Absolute wilderness and certain unique habitats for wildlife must be kept intact. On such areas man can acquaint himself with unspoiled nature and scientists can study the complex ecology of natural communities. Animals threatened with extinction must be totally protected so that man can continue to enjoy and learn from them. Conservation, however, means the wise use of a renewable resource. Trees and most animals of a forest are renewable resources. There is an annual surplus that can be harvested safely by man. Wildlife cannot be stockpiled. Each unit of land has a certain carrying capacity for each species, a limit to the number of that species it can support. A land unit may temporarily support an excessive population (like at the end of the reproductive season), but mortality factors will inevitably reduce the population. Protection will not alter this basic law of population biology. Thus conservation is the process of protecting the environment while taking reasonable befits out of it without causing major damage to it. For example in animal populations safety does not lie entirely in numbers. Wildlife sometimes can be overprotected. The results of allowing a deer herd, deprived of its

natural predators, to multiply beyond the carrying capacity of its habitat have been documented in the past. Poor growth, weakened physical condition, and starvation are sure to follow. The severely damaged forest takes many years to recover, reducing its value for not only deer, but other wildlife as well. The reproductive potential of most animals exceeds the carrying capacity of their habitat (more animals are born each year than the habitat can support). If untouched by humans, the surplus will be removed by mortality factors such as predation, starvation, disease, or other natural causes. If used wisely by humans, the surplus can be harvested without risk to the next year's population. Conservation encompasses the maintenance of environmental quality and resources or a particular balance among the species present in a given area. The resources may be physical (e.g. fossil fuels), biological (e.g. tropical forests), or cultural (e.g. ancient monuments). In modern scientific usage conservation implies sound biosphere management within given social and economic constraints, producing goods and services for humans without depleting natural ecosystem diversity, and acknowledging the naturally dynamic character of biological systems. This contrasts with the preservationist approach of protecting species or landscapes without reference to natural change in living systems or to human requirements. Sustainability: Theory and Practice Under this section two key theoretical concepts in ecology related to economics namely Carrying Capacity and Ecological Footprint (EF) are discussed in detail with the practical solutions to the impeding problems pertaining to same.

2.5 Carrying Capacity

The carrying capacity is the number of individuals an environment can support without degradation. The concept of carrying capacity is used in determining the potential of an area to absorb developmental activities and is

- The level of land use, human activity, or development for a specific area that can be accommodated permanently without an irreversible change in the quality of air, water, land, or plant and animal habitats.
- The upper limits of development beyond which the quality of human life, health, welfare, safety, or community character within an area will be adversely affected.

The concept of carrying capacity also applies to Earth and the human population. Earth's carrying capacity will eventually impact the size of the human population. It has been estimated that the carrying capacity of the Earth is somewhere between 10 billion

and 15 billion people (there is a wide variation in the predicted carrying capacity of earth by various scientists). Human life depends on healthy ecosystems which supply life-sustaining resources and absorb wastes. However, current growth and consumption patterns are placing increasing stress on ecosystems. Environmental degradation, biodiversity loss, deforestation, and the breakdown of social and economic systems are a few of the signs which indicate that ecosystems are stressed. From an ecological perspective, adequate land and associated productive natural capital are fundamental requirement for the existence civilizations on Earth. However, at present, both the human population and average consumption are increasing while the total area of productive land and stocks of natural capital are fixed or in decline. Some scientists argue that the carrying capacity of our planet can be improved by technology such as increased food production from the same land, waste treatment technologies etc. However some argue that the carrying capacity of the planet is going to reach critical leaves due to population growth and increased per capita consumption of resources.

2.6 Ecological Footprint (EF)

The Ecological Footprint is a measure of the load imposed by a given population on nature. It represents the land area necessary to sustain current levels of resource consumption and waste discharge by that population. Your ecological footprint is the biologically productive area required to produce the natural resources you consume and the land required to dispose off the waste you generate. Researchers at the University of British Columbia estimated four to six hectares were required to maintain the lifestyle of each average North American in 1990. The Ecological Footprint provides a systematic resource accounting tool that can help us plan for a world in which we all live well, within the means of our one planet. Ecological footprint calculations are based on two simple facts:

1. We can estimate most of the resources we consume and many of the wastes we generate.
2. Most of these resource and waste flows can be converted to a biologically productive area necessary to provide these functions.

A nation's ecological footprint corresponds to the aggregate land and water area in various ecosystem categories to produce all the resources it consumes, and to absorb all

the waste it generates on a continuous basis, using prevailing technology. The Earth has a surface area of 51 billion hectares, of which 36.3 billion hectares are sea and 14.7 billion are land. Only 8.3 billion hectares of the land area are biologically productive. The remaining 6.4 billion hectares are marginally productive or unproductive for human use, as they are covered by ice. As the population of this planet increases the availability of per capita productive land decreases and this makes it impossible to continue with the present life styles of developed counties. At present the EF of the citizens of developed countries are much higher than that of their under developed counter parts. The EF of many of the countries including India is much more than its actual area. It is the need of the hour to reduce our EF through sustainable life styles.

EF is essentially a concept, seeking to stabilize net global consumption within total production levels and is more concerned with "ecological modernization" to reduce material flows. This concept seeks to force rich consumers to confront the distant economic, ecological and social consequences of their consumption levels and to highlight the need for international agreement on sharing the earth's capacity more equally. As an analytical tool, EF can be used as a measure at community, regional or national level, in order to estimate imported carrying capacity and the gap between actual and "sustainable" consumption levels, based on per capita land demand and global per capita land available.

Another term used in association with ecological footprint is the biocapacity. The biocapacity measures the bioproductive supply, i.e. the biological production in an area. It is an aggregate of the production of various ecosystems within the area, e.g. arable, pasture, forest, productive sea. Some of it is built or degraded land. The biocapacity of earth is estimated as approximately 11.3 billion global hectares. Biocapacity is dependent not only on natural conditions but also on prevailing farming/forestry practices. The EF and biocapacity of an average Indian citizen is shown in the figure for a period of 1961 to 2001.

The global Ecological Footprint was 2.2 global hectares per person (a global hectare is a hectare whose biological productivity equals the global average) in 2001. This demand on nature can be compared with the Earth’s biocapacity, based on its biologically productive area, which is a quarter of the Earth’s surface. The productive area of the

biosphere is an average of 1.8 global hectares per person in 2001. Thus in 2001, humanity's Ecological Footprint exceeded global biocapacity by 0.4 global hectares per person, or 21 per cent. This global overshoot began in the 1980s and has been growing ever since. In effect, overshoot means spending nature's capital faster than it is being regenerated. Overshoot may permanently reduce biocapacity. The global Ecological Footprint can be reduced by the following general strategies.

a. **Increasing or at least maintaining biocapacity:** This requires the following:
    1. Protection of soil from erosion and degradation, and preserving cropland for agriculture rather than urban development.
    2. Protection of river basins, wetlands, and watersheds to secure freshwater supplies
    3. Maintenance of healthy forests and fisheries.
    4. Actions to protect ecosystems from climate change. o Elimination of the use of toxic chemicals that degrade ecosystems.
b. **Improving the resource efficiency with which goods and services are produced:** Over the past 40 years, technological progress has increased the resource efficiency of production systems. But although efficiency gains are critically important, they have not been enough to stop the growth of the global Ecological Footprint.
c. **Reducing the consumption of goods and services per person:** The potential for reducing per person consumption depends on the person's income level. People at subsistence level need to increase their consumption to move out of poverty. But wealthy individuals can shrink their footprint without compromising their quality of life, by cutting consumption of goods and services with a large footprint.
d. **Lowering the global population**: Population growth can be reduced and eventually reversed by supporting measures which lead to families choosing to have fewer children. Offering women better education, economic opportunities, and health care are three proven approaches.

    The above strategies could be implemented through the following specific measures.

    1. Incorporate socio-economic (market and non-market) values of ecosystems and their services in management decisions.

2. Integrate ecosystem management goals in sectors such as agriculture, forestry, finance, transport, trade, and health.
3. Promote agricultural technologies that enable increased yields without causing harm to the environment like excessive use of water, nutrients, or pesticides.
4. Give higher priority to ecosystem restoration and conservation investments as the basis of development.
5. Adopt an ecosystem-based management approach for marine and fisheries policies that provides for a sustainable fisheries sector and protects vulnerable species and habitats such as over-harvested fish species, coral reefs and seamounts.
6. Account in economic terms for the elimination of negative impacts of chemicals on human health and environment to encourage higher development, growth, and innovation.
7. Give deployment funds for regional or national development on the condition of the conservation of nature and ecosystem services.

2.7 Better regulations

1. Provide accurate and relevant information to decision makers and the public about the social and economic value of functioning ecosystems.
2. Develop certification systems to ensure the sustainability of product manufacturing and resource use.
3. Educate the public about the challenges and opportunities of sustainability, addressing issues such as climate change, forests, and fisheries.
4. Eliminate subsidies having adverse social, economic, and environmental effects.

2.8 Trade and development

1. Establish a transparent system to monitor subsidies, lending, and grant mechanisms. Integrate conservation and sustainable use of natural resources in development programmes through country and regional strategy papers.
2. Ensure that development and aid policy is coherent with other policies, particularly in regard to environmental impacts occurring in developing countries. Green infrastructure

3. Work with nature, not against it. Functioning ecosystems provide us with “natural infrastructures”. Wetlands, for example, naturally manage flood risk and treat water.
4. Make transport pricing reflect the full social and environmental costs of road, water, and air travel, and encourage public transport over private car use.
5. Implement comprehensive waste reduction systems, giving priority to controlling hazardous substances.
6. Introduce building design requirements and incentives that reduce waste, and water and energy use.

2.9 Climate change

1. The challenge of moving from a fossil fuel economy is investing in alternatives that truly reduce humanity’s footprint, rather than putting more demand on other ecosystems.
2. Develop certification criteria for non-fossil energy sources to ensure these sources reduce, rather than merely shift, the environmental burden of energy use.
3. Build energy systems that free the country from the high cost of fossil fuel imports while advancing innovation and know-how in new energy technologies

2.10 Limits to growth

Limits to Growth is a book published in 1972 modeling the consequences of a rapidly growing global population by the Club of Rome (The Club of Rome is a Germany based organization that deals with a variety of international political issues.). The book used a model to simulate the consequence of interactions between the Earth's and human systems. The book has sold 30 million copies in more than 30 translations making it one of the best selling environment books in world history. This book predicted that economic growth could not continue indefinitely because of the limited availability of natural resources, particularly oil. The energy crisis of 1973 increased public concern about this problem. Ever since the term limits to growth has become a key concept associated with environmental economics.

The Limits to Growth described the prospects for growth in human population and industrial production in a global system over the next century. A system dynamics model was used to simulate investments in food supply and resource production needed to keep pace with the needs of a growing world. The model also simulated the generation of persistent pollutants and the ability of the environment to absorb and degrade the pollutants to harmless form. The model was used to study futures with widely different estimates of the total food supply, the total resource base, and the role of technology to improve production and efficiency. The simulations led the authors to conclude the world system could not support present rates of economic and population growth much beyond the year 2100, if that long, even with advanced technology. The researchers then used the model to study the most likely pattern of accommodation with the limits in our global system. The major conclusions that can be drawn from this concept are the following.

a. If the present growth trends in world population, industrialization, pollution, food production, and resource depletion continue unchanged, the limits to growth on this planet will be reached sometime within the next one hundred years. The most probable result will be a sudden and uncontrollable decline in both population and industrial capacity.
b. The limits to growth are the more likely outcome given current attitudes and policies about growth, technology and the environment.
c. It is possible to alter these growth trends and to establish a condition of ecological and economic stability that is sustainable far into the future. The state of global equilibrium could be designed so that the basic material needs of each person on earth are satisfied on a sustainable basis and each person has an equal opportunity to realize his individual human potential.

2.11 Equitable use of resources for Sustainable lifestyles

To ensure sustainability it is essential to make equitable use of resources for meeting the basic needs of present and future generations without degrading the environment or risking health or safety. The basis of sustainable lifestyle for the protection of environment is the three R (Reduce, Reuse and recycle).

Reduce: The best thing that we can do for the planet is to use less of it. At the heart of the environmental crisis is our consumer society. Before you buy anything new, ask yourself the following questions.

- Is there another product which would do the same thing but more sustainably?
- Will this last for a long time?
- Do I know how this item was made?
- How it will be used and how it will be disposed off?
- Where was this made and under what circumstances?
- Are the materials used to make this renewable?

Reuse: With the current growing consumerist trends we are often encouraged to buy "new improved products" even if the current one can be repaired. It is better to invest in items which are durable and take care to enhance their longevity as well.

Recycle: Rather than throwing an item out have it recycled. Even though recycling is not perfect (it requires energy and the process of changing something into something else often produces by-products) it is better than sending goods to the landfill or having them incinerated. Find out what types of materials can be recycled in your area. Clean and sort your materials before putting them in the garbage.

The following is a representatice list of things that we could do in our day to day life to make it more sustainable.

2.12 Energy

1. Stay at a place closer to work the work place, or work at home when possible. By reducing travel you can save money and reduce pollution.
2. As far as possible walk, use cycle or public transport system.
3. Carpool and combine trips.
4. Maintain your vehicles well. Without the required maintenance, it can lose considerable percent of its fuel efficiency.
5. Use compact fluorescent (CFL) lamps, which fit into ordinary incandescent light bulb sockets but use far less electricity.
6. Buy energy/fuel efficient appliances with smarter designs.
7. Prefer rechargeable batteries, especially solar powered.

8. Install solar water heaters; they're often cost-effective even in cloudy areas.
9. Turn off all lights, television, fans, air conditioners, computers and other electrical appliances when they are not in use.
10. Reduce air conditioning demands in the summer by installing window blinds and planting trees outside the building.
11. Put on a sweater instead of turning on the heater in the winter.
12. Never run machines (washing machines or dishwashers) half empty

2.13 Water

1. Install low-flow showerheads. With less water to heat, you'll save water and energy.
2. Adopt rainwater in all buildings.
3. Repair leaky pipes without delay. Even small leaks can waste thousands of liters of water a year, and most can be easily repaired by replacing worn parts.
4. Install low-flush toilets which save on flushing water. It saves money as well as water, by cutting utility bills and/or septic tank cleaning charges.
5. Turn the water tap off when you brush your teeth instead of letting it run.
6. Don't water plants during the day because water evaporates more then.

2.14 Food

1. Eat lower on the food chain. Meat, eggs, and dairy products require disproportionately more land, water, and other resources to produce than they return in food value.
2. Buy fruits and vegetables that are grown in your locality.
3. Start a community garden in unused open space.
4. As far as possible avoid fast food. The meat may be contaminated with hormones.
5. Grow at least some of your food. Plant a tomato plant or greens in a pot. Nurturing the food that will in turn nurture you is a very satisfying process.
6. Try to choose foods that are seasonal to your area rather than imported from long distances.
7. Buy produce from a farmer's market whenever possible.
8. Prefer organic produce instead of pesticide-laden produce.
9. Choose not to buy foods and goods that are overpacked.

10. Cut down on meat as a protein source and try to practice a fiber rich vegetarian diet.

2.15 Consumables

1. Use non-toxic cleaning chemicals. Borax, vinegar, baking soda, salt, and lemon juice are a few of the many natural alternatives. Baking soda is a good inexpensive scrubber. Vinegar works fine as a coffee pot and window cleaner.
2. Use non-toxic alternatives to household pesticides.
3. Take a quick look at the list of ingredients in the consumables like shampoos, deodorants, soaps etc. before the purchase.
4. Avoid cosmetics that are animal tested. The labels will specify this. An animal should not die in misery so you can look pretty.
5. Use cloth napkins instead of paper ones.
6. Limit the amount of goods you buy.
7. Use pens that are refillable.
8. Use gas lighters that can be refilled.
9. Bring your own bags with you to the stores.
10. Buy consumables in bulk, and use your own reusable containers to eliminate wasteful packaging.

2.16 Waste generation

1. Make compost, or if you don't want to build your own compost, give your organic waste to friends.
2. Separate recyclables from your garbage, and recycle them.
3. Reuse paper bags, envelopes, etc.
4. Maintain possessions instead of discarding them. With a few tools and by spending a little time you can save money, resources, and landfill space.
5. Start a compost pile with your kitchen scraps in your yard or garden instead of land filling.
6. Use natural composts and fertilizers instead of commercial chemicals to nurture your garden. Run-off from chemical fertilizers is a serious pollutant in our waterways and wells.
7. Make sure you are recycling everything you can.

8. Don't burn garbage or newspapers indiscriminately. They could release toxic heavy compounds like dioxins and heavy metals into the atmosphere.
9. Recycle single-use batteries instead of throwing them in the trash, from where the dangerous metal content can leach into the waterways.

2.17 General

1. Be politically active. Inform politicians of your concern for the environment. Lobby your government officials for renewable energy and better public transportation.
2. Form a group in your community to discuss climate change and call for action at the local level.
3. Educate people about climate change. You could write a letter to the editor of your local newspaper about energy and global warming.
4. Plant shade trees on the western side of the residence to get cooling effect in summer.
5. Take down your back fence. Share garden space and play areas with your neighbors.
6. Substitute materials can be less environmentally benign
7. Educate yourself and don't be greedy. Surf the web for current information.
8. The root cause of all our environmental problems (and probably many of our social problems too) is that there are too many humans on the planet. The web of life is in a precarious position as humans push other species out.
9. Choose to have not more than two children.
10. Adopt children.
11. Don't use antibiotics unless you absolutely must. Many disease strains no longer respond to antibiotics, in part because of overuse.
12. Make sure you are practicing safe sex. AIDS is becoming the number one cause of death among young people.
13. Buy clothes and materials that are manufactured by adult workers who receive a fair wage and work in decent conditions in a non-polluting factory. You must do your homework here, be persistent and ask a lot of questions. Nike and Reebok are examples of products that are not produced under just or human conditions.

2.18 Benefits of sustainable lifestyles

The benefits of sustainable lifestyles include the following.

1. Direct financial savings. By serving more people and serving them longer before new landfills, roads and utilities have to be built and operated, substantial financial savings are possible.
2. Enhancing community environmental quality. From reduced air and water pollution to fewer problems with toxic and hazardous substances to less traffic congestion, communities will be cleaner, safer, and higher quality places to live.
3. Strengthening the fabric of the community by reinforcing neighborhood relationships and enhancing the capacity of citizens to take responsibility for helping themselves and each other.
4. Expanding environmental literacy and building a citizenry that is environmentally motivated.
5. Increasing local government revenues.
6. Achieving more effective, economical, and equitable compliance with state and central environmental regulations and requirements.
7. Improving the relationship between local government and its citizens. By building active working partnerships with citizens to recycle and conserve resources.
8. Building consumer demand for environmentally sustainable products and services so that it is economically profitable for businesses to meet this demand.
9. Starting a process that catalyzes citizen participation in creating a sustainable community, where progress toward the interdependent goals of prosperity, social equity, environmental protection, governmental efficiency, and a higher quality of life can be sustained for the generations to come.

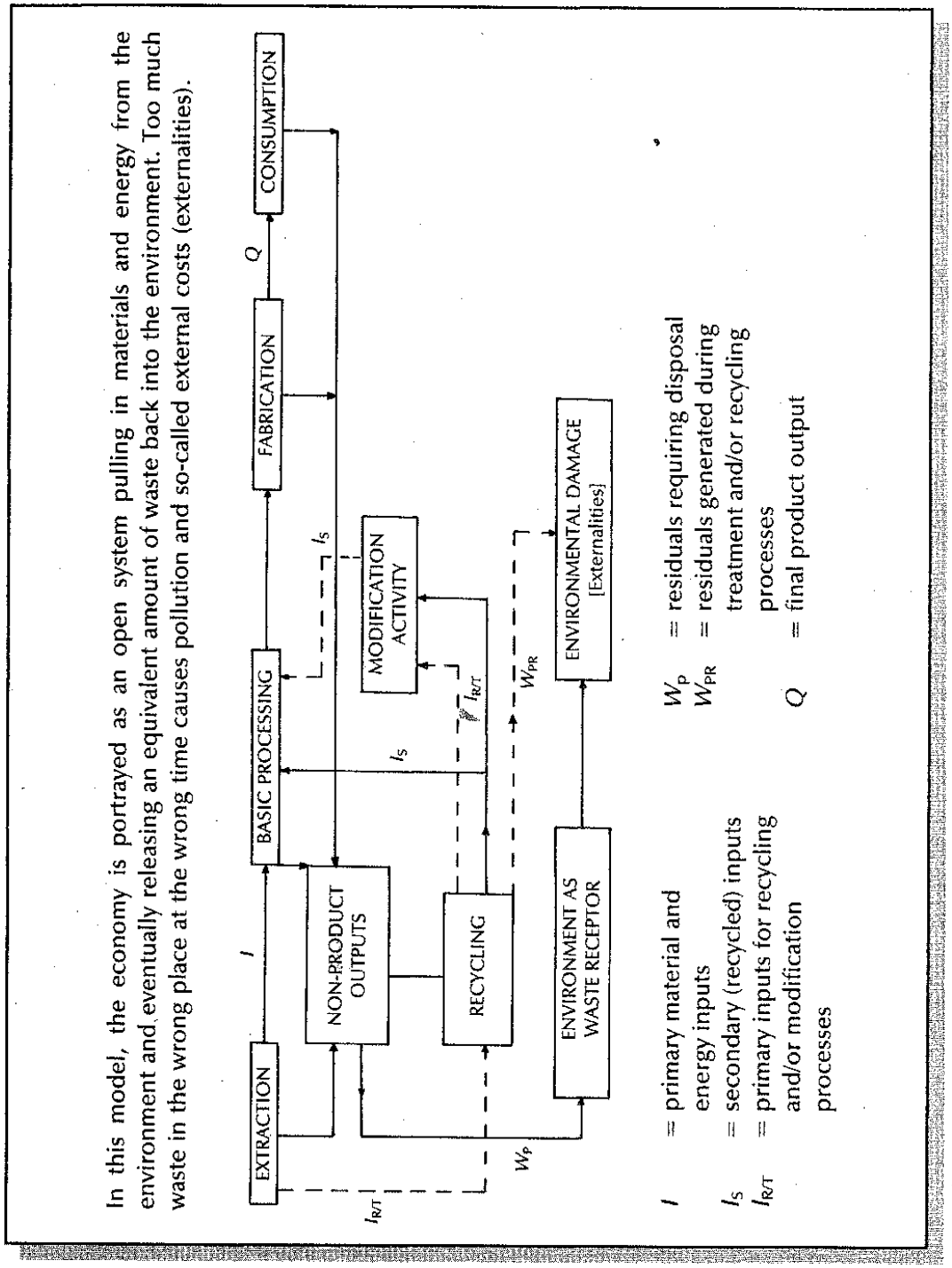
2.20 MATERIAL BALANCE MODEL:

Environmental economics takes as its starting point the lessons to be drawn from the 'laws' of thermodynamics. The economy-environment interactions are best portrayed via the materials balance model, based on the First and Second Laws of Thermodynamics, as shown in Box 1.2. The model represents the economy as a materials processing and product transformation system. 'Useful' materials are drawn into the economic system (e.g. non-renewable resources sush as fossil fuels can be

extracted until their stocks are exhausted and renewable resources such as fisheries and forests can be harvested) and then undergo a series of changes in their energy and entropy (i.e. usefulness) states. Eventually after a time lag, the non-product output of the system can be partially recycled with the residual 'useless' materials (wastes) returned to the environment from various points in the economic process, see Box.1.1.

The materials that first enter the economic system are not destroyed by production and consumption activities; they are however, dispersed and chemically transformed. In particular, they enter in a state of low entropy (as 'useful' materials) and leave in a state of high entropy (as 'useless' materials, such as low temperature heat emissions, exhaust gases, mixed municipal wastes, etc.). At first sight, the entropy concept seems counter-intuititive and it is not used formally or defined rigorously in this discussion. In lay terms, entropy is a certain property of systems which increases in any irreversible process. When entropy increases, the energy in the system becomes less available to do 'useful work'. No material recycling process can therefore ever be 100 percent efficient (Ayres and Kneese, 1989). Once the materials balance perspective is adopted, it is easy to see that the way humans manage their economies impacts on the environment and, in the reverse direction, environmental quality impacts on the efficient working of the economy.

Box: 2.1. Simplified Material Balance Model



2.21 SERVICES OF THE ENVIRONMENT

In the previous section we noted that the environment provides human beings with a range of services. Indeed, this is how mainstream economic analysis of the environment tends to view the economy-environment relationship.

2.21.1 Life support

The most important service is that of 'life support'. One can debate the minimum requirements for life support, but few would question the need for breathable air, a temperature range capable of sustaining human life, sufficient amounts of food and water, and protection from harmful levels of solar radiation. The environment performs numerous functions in its life-support capacity, many of which also relate to the maintenance of sufficient environmental stability for human survival - eg limiting the incidence of catastrophic flooding and extreme weather. The ability of the environment to provide life-support services will depend, in part, on the size of the population, on the state of food production technology, and the demand for other environmental services.

Whilst the earth probably still has some way to go in terms of the maximum population it could potentially support, in practice, its carrying capacity depends on the extent to which resources are diverted from food production to other productive activities, and how much of the natural environment is left intact to sustain non-human life. The diversion of resources away from basic life-support functions is clearly problematic for some of the world's poorest people given the existing distribution of income and assets. However, at a global level, maximising the earth's human life-support capabilities (in terms of population) is not something that is ever likely to be achieved, or, indeed, desired.

2.21.2 Resources for production

The environment's function as a supplier of raw materials is clearly a pivotal part of the economy-environment relationship and is the focus of natural resource economics. We have already discussed some of the characteristics of this service in our classification of resources in Section 1 of this unit. Resources can be renewable or non-renewable and take the form of stocks and flows. Some resources can be easily substituted with other resources, but many cannot. For some resources, extraction rates can be slowed through

recycling (metals and timber, for example), but recycling is not always possible (eg in the case of oil and coal).

2.21.3 Waste sink

The environment acts as a sink for the waste products of economic activity. It is a place to dispose of the unwanted by-products of production and consumption - above all in a manner and place which ensures that the waste (whether in solid, liquid or gaseous form) does not cause harm or inconvenience to human beings. The environment has the physical capacity to assimilate certain quantities of waste in ways that meet these requirements.

The ecological systems that constitute the environment operate through the perpetual recycling of outputs from natural processes to produce each new generation of living organisms and each consecutive stage in the cyclical transformation of inorganic matter, such as in the nitrogen cycle or the hydrological cycle. Waste products from the human economy can be absorbed by these processes, toxic wastes can be filtered or diluted to render them harmless to human health, wastes that are slow to decay or decompose can be buried in places where they will cause little harm.

How well the environment fulfils this waste sink function depends upon the quantity and quality of waste that is produced and the methods of disposal. The environment's assimilative capacity is not limitless. Too much waste of the wrong sort and in the wrong place can reduce the environment's assimilative capacity, damaging not only natural ecosystems but also the protection they afford to humans against the pollution caused by their own waste.

2.21.4 Amenity services

Environmental and natural resource economics, with their roots in neoclassical welfare economics follows a utilitarian ethic. This means that the value of things is measured by the utility or satisfaction they bestow upon people, whatever the source of that utility may be. Amenity services relate to the pleasure and satisfaction that people derive from the environment for any reason other than its life-support, resource reservoir, and waste sink functions.

The analysis of amenity value is the preserve of environmental economics, rather than natural resource economics. Nevertheless, in studying natural resource economics one obviously needs to be aware that the exploitation of natural resources as raw materials for production and consumption can damage the environment's amenity services, either directly through the extraction process or indirectly via the pollution created by production and consumption. Any economic analysis of natural resource exploitation that does not account for significant damage of this sort will be incomplete. That is why natural resource economics and environmental economics are complementary rather than competing disciplines.

2.22 FUNCTIONS OF ENVIRONMENT: ASSIMILATIVE CAPACITY OF ENVIRONMENT

Functions of the Environment: Environment performs valuable service to the economy by dispensing- storing and assimilating the residuals and waste by products generated due to economic activity.

It is a natural process that waste products into harmless and at times valuable transforms the potentially harmful concentration substances. Wind currents disperse of air pollutants. Rain and gravity remove pollutants from the air. In some cases, air pollution undergoes chemical change to become less harmful or even useful. Bacteria in water feed on and transform organic wastes into inorganic nutrients for algae, the first link in the aquatic food chain.

2.23 LIMITED ASSIMILATIVE CAPACITY OF ENVIRONMENT

If the capacity of the environment to assimilate the waste product is unlimited, then there will be no problem of pollution at all. Residuals can be dumped into the environment without any limit and cost. But, the assimilative capacity of the environment is limited in several ways. For example, bacteria feeding on organic residuals use oxygen. If the supply of oxygen is depleted, the aquatic life will be affected. Some materials, such as the heavy metals are not degraded by natural forces, and they accumulate in the environment when they are ejected by producers. Mercury and some other heavy metals are examples in this point. Organic forms of mercury may get concentrated in the food chain by natural process. As a result, a relatively small amount of mercury in the environment in the non-toxic form, may eventually swell up in harmful way through fish

population. Many examples can be cited to establish that the assimilative capacity of the environment is limited and residuals can impair environmental functions and services.

The second, perhaps, very important service rendered by the environment is the support of human life. Life on this earth has been made hospitable for human beings because of the generosity of the environment. – Food, clothing and shelter, cultural development habits, lobe due and habitats, sports and pastimes and all are possible on this to the congenial environment for a health living. Of course, the atmosphere may be less hospitable as residuals accumulate in it causing ill-health and poor life expectancy. Pollution in the atmosphere in large concentration may alter seriously the ecological system to harm human life in the long run.

Thirdly, the services rendered by environment could be called amenity services. Some parts of the globe are pleasant spots, where people engage themselves in recreational activities like hiking, camping and boating. The environment can provide amenity services by being pleasant. A pleasant lake, very useful for swimming and boating could be made unfit and utterly useless, by the disposal of human wastes and septic tank flows into the lake.

Finally, the environment serves as a source of material inputs to the economy. These include fuels, minerals, water from rivers, gases from atmosphere and fish from the seas. The quality of these material flows can be impaired by residual discharges, thereby increasing the cost of obtaining our requirements of food and other materials from the environment.

2.24 ENVIRONMENTAL QUALITY: MEANING AND FORMS

Definition of Environmental Quality

The environmental quality can be defined as ‘level and competition of the stream of all environmental services, except the waste receptor services’. In principle, environmental quality can be measured in terms of the value the people place on these non-waste receptor services or the willingness to pay.

Due to the imperfect market system for environmental quality, no one can fix a price on it. Environmental quality is definitely a consumption public good as it possesses the basic characteristic feature of a public good namely, ‘non excludability and non-rivalry’.

The environment as a public good can be used in two ways:

1. It provides consumption goods that can be measured quantitatively, i.e., in physical units.
2. It provides inputs, which are qualitatively valued and used in industrialization.
3. People enjoy all amenities provided by nature at zero costs, but overexploitation of the same has resulted in them becoming scarce. This condition has an adverse effect on the standard of living of the people.

Hence, in order to maintain the existing level of environmental quality, people are willing to pay more to improve their welfare and their living condition. Moreover, environmental quality as a public good is meant to be used by all in equal amounts.

2.25 Forms of Environmental Quality

The major forms of the environmental quality can be classified as follows:

1. Air
2. Water
3. Forest
4. Land, Etc.

I. Air as an Environmental Quality

Atmosphere is the life blanket of the earth, the essential ingredient for all living things. Air covers every part of the two hundred million square miles of the earth's surface. Air is the most commonly used natural resource, which cannot be excluded by any individual and this is the root cause for it being polluted to the core by the people.

Air Pollution

It is defined as "the presence in the outdoor atmosphere of one or more contaminants or combinations thereof, in such quantities and of such duration as may be, or may tend to be injurious to human, plant or animal life, or property, or the conduct of business."

2.26 Sources of Air Pollutants

There are different types of air pollutants. They are classified into primary and secondary pollutants. Primary pollutants are those, which are remitted directly into the atmosphere and the secondary are derived from the primary pollutants due to some chemical reactions in the atmosphere.

The Most Common Sources of Air Pollution

1. Carbon monoxide released from motor vehicles, engines powered with petroleum derivate used for transportation and heating.
2. Hydrocarbons mostly discharged by motor vehicles and also from exhausts of industrial plants.
3. Nitrogen oxides released by motor vehicles, power plants and industrial establishments.
4. Sulphur oxides released mostly by motor vehicles, power generating plants and industrial units.
5. Particulate matter coming out of power plants, industries and waste disposal.
6. Natural pollutants like pollen, volcanic gases, marsh gases etc.

2.27 Effects of Deteriorating Air Quality

1. On Humans

Polluted air enters the human body mainly through the respiratory system and pollutants in the air make their access into the throat, lungs and other parts of the respiratory organs. This can cause diseases like bronchitis, tuberculosis, asthma, influenza etc.

2. On Animals

Polluted air may gain entry through forage crops consumed by the livestock, as the air-borne contaminants accumulate in vegetation and fodder. Fluorides, lead and arsenic pollutants are very injurious to livestock.

3. On Plants

Air pollution can cause serious damage to plants and vegetation. The damages can manifest in the form of visual injury, such as, yellowing, marking and banding of the leaves resulting in retardation of plant growth and final extinction.

II. Water as an Environmental Quality

Water as an environmental quality is very essential for human existence and also for all living organisms. It is necessary for the survival of any form of life. It accounts for about 70% of the weight of human body. But due to rapid increase in the population and fast industrialization most of the water resources are being degraded and polluted.

Water Pollution

Water is polluted when there is a change in its quality or composition, directly or indirectly as a result of human activities, so that it becomes useless or less suitable for drinking. It may be defined as "any human activity that impairs the use of water as a resource.

The real menace of water pollution arises from sewage, industrial wastes and a wide array of synthetic chemicals being discharged into the water sources like rivers, streams or lakes. Many industries effluents have joined rivers and lakes, which supply water and are degraded by the flora and fauna present in the rivers. A state is reached when the content in the river becomes toxic, unfit for any use.

2.28 Classification of Water Pollution

Water pollution is classified into five broad categories.

2.28.1 Organic pollutants:

This can further be classified as

- Oxygen demanding wastes
- Disease-causing wastes
- Synthetic organic compounds
- Sewage and agriculture run-off and
- Oil pollution.

2.28.2 Inorganic pollutants

Finely divided metals, metal compounds, cyanides, sulphates, nitrates, mineral acids, inorganic salts etc., form inorganic pollutants in water. Various metals and metallic compounds released from anthropogenic activities add up to their natural background levels in water, which play a vital role in biological processes which prove toxic to biota.

2.28.3 Suspended solids and sediments

These pollutants are mainly due to soil erosion. Sediments are mostly contributed by the process of erosion, agricultural development, mining and construction activities. Soil erosion has been one of the major problems in India. Apart from the soil losing its fertility and productivity, the siltation results in reducing the storage capacity of reservoirs.

2.28.4 Radioactive materials

The radioactive water pollutants may arise from mining processing of ores like uranium tailings; use of radioactive isotopes in agricultural, industrial, medical research and applications; radioactive materials due to testing and also use of nuclear weaponry.

2.28.5 Heated effluents:

Many industries using water as a coolant, dispose off the waste hot water by returning it into the original water bodies.

2.29 Effects of Water Pollution

In most of the developed countries water-borne diseases are eradicated but not so with the developing countries. Water is a significant vehicle in the transmission of disease when it contains water-borne pathogens or disease producing organisms.

2.30 On Industries

Water pollution may reduce the utility of water for industrial proposes. The range of quality required by the industries is very wide. Cooling water can often be of comparatively low sanitary quality but the presence of waste heat and of corrosive material is undesirable.

So polluted water requires high cost for the industries the cost of purifying the water, of repairing damaged equipment or of making extensive adjustments to the industrial processes themselves.

2.31 On Agriculture

Water pollution can greatly affect the productivity of irrigated land. Irrigation itself is a major cause of water pollution. All natural water contains inorganic salts, particularly chloride. As irrigation water evaporates in the field, the salt concentrates in the wet soil. If this is allowed then the fertility would diminish and eventually land would become barren. If this is done with subsequent heavy rainfall then the damage would be less.

2.32 On Aquatic Food Resources

The effects of the water pollution on fisheries are drastic. Fish may be killed by specific toxins or through oxygen depletion. Their breeding is affected due to the change in the temperature and the food may be spoiled through changes in flavor by pathogenic organisms. The best example of the affect of the water pollution on aquatic life is the

"minamata tragedy" where nearly forty people died after eating the fish caught in Japan's minamata bay.

2.33 Control of Water Pollution

The water pollution can be controlled only by the treatment of the effluents discharged by the industries and treating the sewage by providing for more sewage treatment plants. This sewage treatment proceeds in three stages.

At first through mechanical and biological process the solid wastes and the organic matters are removed. Virtually all the remaining pollutants are removed in the tertiary stage. But for complete removal of pollutants more advanced treatments are used.

They are:

1. Chemical coagulation method
2. Chemical oxidation method
3. Carbon absorption method
4. Ion exchange method
5. Electro dialysis and
6. Reverse osmosis.

With all these methods the water pollution can only be controlled when all the human beings realize their moral responsibility towards protecting water.

III. Forests as an Environmental Quality

Forest is a peculiar organism of unlimited kindness and benevolence. It makes no demand from the human beings but supplies the product for their life and activity, they help mankind as producers and as custodians of favourable environmental conditions. They provide food, fuel, fibre, building material, industrial products, packaging materials, textiles and clothing as well.

2.34 Destruction and Deforestation:

Apart from the services rendered by the forest it is destroyed for economic development and growth, all over the world. Deforestation is taking place at a faster speed.

The principal causes of deforestation are:

1. Logging and timbering, as an industry.
2. Overgrazing by cattle.

3. Clearing land for colonization and urban development.
4. Clearing land for cultivation and pasture.
5. Natural forest fires.
6. Felling of trees for fuel.

2.35 Effects of Deforestation

2.35.1 On Climate

Forest helps to maintain the temperature at a low level and prevent it from rising. A portion of the solar radiation is reflected back into the space by earth's atmosphere. The rest reaches the surface of the earth as much is not absorbed by the atmosphere.

The forest present on earth will reflect back a portion of sunrays again into the outer space and we call it as the "albedo". In the absence of forest, the entire heat that is not absorbed by the atmosphere strikes the earth's surface, leading to a rise in atmospheric temperature.

But if forest cover would be thick and wide, this heat would be absorbed and the rise in temperature is prevented. Sometimes the ultra-violet- rays are absorbed by the ozone layer. But due to certain pollutants like chlorofluorocarbons, a hole is formed in the layer. Under such conditions the forests would serve as a natural filter of the ultra-violet- rays which threaten the health of the people.

2.35.2 On Soil

Forests protect soil and deforestation can cause soil erosion. When trees are felled and the root-mat is destroyed, the soil is subject to erosion by the full force of the rains. Heavy rain removes nutrients by washing away the thin top layer of soil and by leaching nutrients deep into the sub-soil thus making it unavailable to plant roots.

Forest is the home for a large variety of animals and deforestation would lead to extinction of the species. Since forests exert a tremendous influence in maintaining ecological balance, they need to be preserved. Afforestation projects should be given more priority.

IV. Land as an Environmental Quality

Land is a distinctly limited resource, which is central to all human's needs and activities. It provides a foundation for all economic activities and a base for all natural

resources. Without it, we would be flying in the air. In simple words, land can be referred as earth's surface, on which all types of human activities are possible.

Land has been used for agricultural activities like irrigation, ploughing, sowing etc. It has been used for urbanization and housing purposes. It is the base for industrialization. Man depends on land for transport. Land, being covered by forests, mountains and deserts is also source of energy. Hence, land is also known to be a part of environmental quality.

Increase in population and overexploitation of resources has resulted in land abuse. The present rate of growth of population would leave people fighting with each other for land. Land's productivity depends on soil types and its fertility. But man has been destroying forests for wood, which is major source of fire and shelter, and also for space for habitation. This process of deforestation would lead to soil erosion resulting in the reduction of soil fertility, which in turn would have adverse effects on agricultural production. Attempts to increase food production to meet needs of the ever-growing population, overgrazing by cattle, irrigation schemes without proper drainage system and the single cropping method of cultivation are other causes of decrease in land fertility. Thus, it is important to realize the need to protect land from becoming a desert and to prevent a condition of draught. An efficient afforestation policy in order to conserve forests, enforcing laws to regulate the use of urban land, proper control measures to prevent unnecessary encroachment of agricultural land, are some of the measures to be adapted by the state and central governments to protect land from becoming an arid zone.

There is a long-standing debate on the relationship between economic development and environmental quality. From a sustainable development viewpoint there has been a growing concern that the economic expansion of the world economy will cause irreparable damage to our planet. In the last few years several studies have appeared dealing with the relationship between the scale of economic activity and the level of pollution. In particular, if we concentrate on local pollutants many empirical contributions have identified a bell-shaped curve linking per capita pollution to per capita GDP (in the case of global pollutants like CO_2 the evidence is less clear-cut). This behavior implies that, starting from low per capita income levels, per capita emissions or concentrations tend to increase but at a slower pace. After a certain level

of income (which typically differs across pollutants) – the "turning point" – pollution starts to decline as income further increases. In analogy with the historical relationship between income distribution and income growth, the inverted-U relationship between per capita income and pollution has been termed "Environmental Kuznets Curve".

UNIT – III

CONSERVATION OF RESOURCES

3.1 Introduction

Water Conservation is the preservation, control and management of water resources. Water Conservation is important on site to reduce the amount of water used and to contribute to the sustainable use of water. It is required in order to ensure the conservative use of water during drought and other water shortages as well as reducing pressure on rivers and streams used for water abstraction. Water conservation includes all the policies, strategies and activities to sustainably manage the natural resource of fresh water, to protect the hydrosphere, and to meet the current and future human demand.

3.2 ENVIRONMENTAL DEGRADATION

Environmental degradation comes about due to erosion and decline of the quality of the natural environment. It is caused directly or indirectly by anthropogenic activities that extract various environmental resources at a faster rate than they are replaced, and thus depleting them. On this regard, degradation means damage or reduction in quality of environmental features, primarily influenced by human activities. Some natural events such as landslides and earthquakes may also degrade the nature of our environments.

Continued environmental degradation can completely destroy the various aspects of the environment such as biodiversity, ecosystems, natural resources, and habitats. For instance, air pollution can lead to the formation of acid rain which can in turn reduce the quality of natural water systems by making them acidic. This is a typical example of environmental degradation. Environmental degradation is therefore a concept that touches on a variety of topics namely deforestation, biodiversity loss, desertification, global warming, animal extinction, pollution, and many more.

3.3 CAUSES OF ENVIRONMENTAL DEGRADATION

3.3.1 Overpopulation and Over-exploitation of Resources

As the human population keeps on enlarging, there is a lot of pressure on the utilization of natural resources. This often causes over-exploitation of the natural resources, and contributes to environmental erosion. According to a study by the UNEP Global Environment Outlook, excessive human consumption of the naturally occurring

non-renewable resources can outstrip available resources in the near future and remarkably destroys the environment during extraction and utilization. Overpopulation simply means more pollution and fast extraction of natural resources compared to how they are being replaced.

3.3.2 Ruinous Agricultural Practices

Intensive agricultural practices have led to the decline in quality of most of our natural environments. Majority of farmers resort to converting forests and grasslands to croplands which reduces the quality of natural forests and vegetation cover. The pressure to convert lands into resource areas for producing priced foods, crops, and livestock rearing has increasingly led to the depreciation of natural environments such as forests, wildlife and fertile lands.

Intensive agricultural practices destroy fertile lands and nearby vegetation cover due to the accumulation of toxic substances like bad minerals and heavy metals which destroy the soil's biological and chemical activities. Runoffs of agricultural wastes and chemical fertilizers and pesticides into marine and freshwater environments have also deteriorated the quality of wild life habitats, natural water resources, wetlands and aquatic life.

3.3.3 Landfills

One of the calamitous effects of landfills is the destruction of nearby environmental health together with its ecosystems. The landfills discharge various kinds of chemicals on the land adjacent to forest, various natural habitats, and water systems such as underground and surface water which makes the environment unappealing to the survival of trees, vegetations, animal and humans.

It even interferes with the animals interactive food chains because the chemicals contaminate plants, and waters which are consumed by the animals. Besides the foul smell from the landfills and periodic burning of the wastes make living in such environments unbearable.

3.3.4 Increase in Deforestation

The act of deforestation (cutting down of trees) has impacted on the world in terms of depreciating the natural environment and wildlife. It has also impacted on humans on the account of changes in environmental support processes such as weather conditions. Some of the reasons for deforestation include farming, construction,

settlement, mining, or other economic purposes. For more than one hundrend years, the number of trees on the planet has plummeted, resulting in devastating consequences such as biodiversity loss, soil erosion, species extinction, global warming, and interference with the water cycle.

3.3.5 Environmental Pollution

Most of the planet's natural environments have been destroyed and a large portion is under huge threat due to the toxic substances and chemicals emitted from fossil fuel combustions, industrial wastes, and homemade utilities among other industry processed materials such as plastics. Land, air, and water pollution pose long-term cumulative impacts on the quality of the natural environments in which they occur. Seriously polluted environments have become insignificant in value because pollution makes it harsh for the sustainably of biotic and abiotic components. Pollution impacts the chemical compositions of lands, soil, ocean water, underground water and rocks, and other natural processes. Air pollution from automobiles and industries that results in the formation of acid rain which in turn brings about acidic lake is a good example of how the environment is degraded by pollution.

3.3.6 Improper Land use Planning and Development

The unplanned conversion of lands into urban settings, mining areas, housing development projects, office spaces, shopping malls, industrial sites, parking areas, road networks, and so on leads to environmental pollution and degradation of natural habitats and ecosystems. Mining and oil exploration, for instance, renders land unusable for habitation and causes other forms of environmental degradation by releasing toxic materials into the environment. Improper land use has led to the loss and destruction of millions of acre of natural environments across the globe.

3.3.7 Natural Causes

Despite the fact that environmental degradation is under normal circumstances associated with anthropogenic activities, natural causes are also contributors. Natural events such as wildfires, hurricanes, landslides, tsunamis and earthquakes can totally lower the survival grade of local animal communities and plant life in a region. These disasters can also destroy alter the nature of the landscape rendering it unable to support life forms on it. Besides, occurrences such as hurricanes and flooding can wash or force

the migration of invasive species into foreign environments which can lead to its eventual degradation.

3.4 Effects of Environmental Degradation

3.4.1 Impact on Human Health

Human health is heavily impacted by environmental degradation. Reduction in water quality is responsible for more than two million deaths and billions of illness annually across the globe. Due to environmental degradation, the results include water scarcity and decline in quality foods. Reduction in air quality is responsible for more than 300,000 deaths annually and millions of chronic diseases. Landfills increase the risk of hazardous materials getting into the food chain which causes biomagnification and the ultimate risk of developing chronic diseases. Altogether, the toxic wastes and harmful chemicals from factories, agriculture and automobiles cause illnesses and death in children and adults.

3.4.2 Poverty

In the majority of developing countries, poverty is attributed to poor crop harvests and lack of quality natural resources that are needed to satisfy basic survival needs. The inadequacy basic survival resources and lack of quality of food is the direct result of environmental degradation in the regions. Most vulnerability situations brought about by water shortages, climate change, and poor crop yields in developing countries are tied to environmental degradation. Hence, the lack of access to adequate basic needs such as water and food directly induce poverty.

3.5 Water Pollution

Pollution occurs when pollutants contaminate the natural surroundings; which brings about changes that affect our normal lifestyles adversely. Pollutants are the key elements or components of pollution which are generally waste materials of different forms. Pollution disturbs our ecosystem and the balance in the environment. With modernization and development in our lives pollution has reached its peak; giving rise to global warming and human illness. Pollution occurs in different forms; air, water, soil, radioactive, noise, heat/ thermal and light. Every form of pollution has two sources of occurrence; the point and the non-point sources. The point sources are easy to identify, monitor and control, whereas the non-point sources are hard to control. Let us discuss

the different types of pollutions, their causes and effects on mankind and the environment as a whole.

Water Pollution has taken toll of all the surviving species of the earth. Almost 60% of the species live in water bodies. It occurs due to several factors; the industrial wastes dumped into the rivers and other water bodies cause an imbalance in the water leading to its severe contamination and death of aquatic species. If you suspect that nearby water sources have been contaminated by a corporation then it might be a good idea to hire an expert to see your options.

Also spraying insecticides, pesticides like DDT on plants pollutes the ground water system and oil spills in the oceans have caused irreparable damage to the water bodies. Eutrophication is another big source; it occurs due to daily activities like washing clothes, utensils near lakes, ponds or rivers; this forces detergents to go into water which blocks sunlight from penetrating, thus reducing oxygen and making it inhabitable.

Water pollution not only harms the aquatic beings but it also contaminates the entire food chain by severely affecting humans dependent on these. Water-borne diseases like cholera, diarrhoea have also increased in all places.

3.6 CONSERVATION OF WILDLIFE

Nature – a physical setting where emerald and verdant greenery of flora and variety of beautiful fauna are dwelling peacefully in the wilderness making it pleasant and blissful. Sometimes aesthetically and more often for satiating the basic necessities, people's inclination towards nature is always treated beautifully, because generosity of nature knows no limit. It is true that people carry out anything to get their wish nurtured and they do not mind abandoning the god's gift i.e. nature. Our Mother Earth is adorning a thick layer of plants, trees, etc, while the diverse kingdom of wild animals is keeping the environment alive with their unique presence. Apart from the biosphere budding on the Earth, human beings are heavily tapping the natural resources that have brought many wild animals on the verge of extinction. And, not to forget the extreme weather conditions, which are also repercussions of human activity. Since, there is no substitute of Mother Earth, and also no other way to dwell in peacefully in the nature, here are some steps that will act as a savior in current alarming situation.

Wildlife conservation is the practice of protecting animal species and their habitats. It is achieved partially through legislation such as the Endangered Species Act, the establishment and protection of public lands, and responsible public practices that conserve wild animal populations. Read answers to the following FAQs to learn how wildlife is protected in the United States.

3.7 What does the Endangered Species Act do?

The Endangered Species Act (ESA) of 1973 is our nation's strongest law protecting wild plants and animals. It is enforced by the U.S. Fish and Wildlife Service (USFWS)and the National Marine Fisheries Service. Under the ESA, a species can be designated as "threatened" or "endangered". Threatened and endangered species are protected under the provisions of the ESA, which restricts human activities that may harm these species and their habitats. Due in parts by protections under the ESA, many species have been brought back from the brink of extinction.

The role of economics in analysing land use options, in particular the potential contribution of economics in assessing foregone biodiversity and other non-market environmental values lost through destructive exploitation of tropical forests for timber. The failure to take into account these foregone values may mean that timber exploitation is 'excessive'. However, precisely because such values are unknown and involve future impacts they are difficult to assess. The practical application of economic analysis to the valuation of environmental benefits of tropical forests, especially for biodiversity conservation, and the wider policy considerations involved in such valuation.

3.8 CONSERVATION OF FORESTS

An important aspect of the economic approach to tropical forests is to view them as a form of 'natural' capital or 'environmental' asset. That is, they have the potential to contribute to the long-term economic welfare of tropical forest countries. Thus the value of a tropical forest as an economic asset depends on the discounted value of its income, or welfare, potential. However, in any growing economy there will be other assets, or forms of wealth, that yield income. Any decision to retain a tropical forest therefore implies an opportunity cost in terms of foregoing the chance to invest in alternative income-yielding assets, such as man-made 'reproducible' capital. If tropical forests are to be an 'efficient' form of holding on to wealth, then they must yield a rate of return that is

comparable to or greater than that of other forms of wealth. Thus an 'optimal' strategy for a developing country would be to reduce its stock of tropical forests to finance economic development by reinvesting the proceeds in other assets that are expected to yield a higher economic return. Under such circumstances, deforestation is not an economic problem but is in fact economically justified; it should proceed up to the point where the comparative returns to 'holding on' to the remaining forest equal the returns to alternative investments in the economy. If the latter always exceeds the former, then even complete deforestation is economically 'optimal'.

However, there are obvious limits to the applications of the above rules to reality. In the first place, if we are interested in maintenance of the per capita value of this asset base over time, then we should be concerned about the rapid rate of population growth in developing countries - particularly its implications for both the conversion of tropical forests and its depreciation in per capita value through both use and population growth. Moreover, the above rules also assume that all economic values are known and reflected in the 'prices' of resources, markets are undistorted, resource extraction is efficient and any returns are reinvested in other assets in the economy. In fact, there is little evidence to suggest that tropical forest resources are currently being exploited efficiently, nor that the rents earned from activities that degrade or convert the forests are being reinvested in more 'profitable' activities. Rather, market and policy failures are often rife, and economic rents tend to be dissipated and misused. More recent theories now stress the limits to 'substitution' between many forms of natural and man-made capital, even for developing countries interested in 'drawing down' their natural capital stock in favour of investing in other forms of capital (Barbier, 1989; Pearce, Barbier and Markandya, 1990).

3.9 SOIL CONSERVATION

Soil erosion is widely considered to be a serious threat to the long-term viability of agriculture in many parts of the world (e.g. El-Swaify et al., 1985). This concern is not without precedent. Human history contains many examples of previous civilizations whose downfall was caused at least in part by excessive soil erosion and the deterioration of the agricultural base (Lal, 1990; Hudson 1971). The problem is particularly serious in certain developing countries, where the importation of food to substitute for declining domestic production due to soil erosion, and the growing scarcity of arable land may be

severely constrained by low foreign exchange earnings and high external debt burdens. In other cases, agricultural products may themselves constitute a country's main source of foreign exchange. Declines in agricultural productivity resulting from soil erosion would therefore hinder such a country's economic development, particularly in the absence of other export opportunities. In addition, many countries can anticipate continued expansion of agricultural production, for either domestic consumption or export, due to rapidly expanding populations. Given that rapid rates of soil loss are occurring on farms in many parts of the world, a logical place to begin to look at the issue from an economic perspective is at the farm level.

Lal (1990) points out that confusion often arise over the relationship between the terms soil erosion, soil depletion and soil or land degradation. Soil erosion refers to a loss in soil productivity due to:

"Physical loss of topsoil, reduction in rooting depth, removal of plant nutrients, and loss of water. Soil erosion is a quick process. In contrast, soil depletion means loss or decline of soil fertility due to crop removal or removal of nutrients by... water passing through the soil profile. The soil depletion process is less drastic and can be easily remedied through cultural practices and by adding appropriate soil amendments" (Lal, 1990).

Soil degradation is a broader term for a decline in soil quality encompassing the deterioration in physical, chemical and biological attributes of the soil. Soil degradation is a long term process which may be enhanced by, among other things, accelerated soil erosion. Society is concerned about soil erosion primarily because of its contribution to longer term soil degradation, which is often irreversible. Attention focuses on soil erosion because it is a visible and measurable process and because it can be dramatically increased by human actions. In contrast, soil degradation consists of many interrelated processes and defies easy quantification.

Soil erosion is not only an agricultural problem. It is associated with a host of environmental, social and economic issues. It has also been acknowledged as a major setback for food security and a serious problem for sustainable development. One of the factors that accelerate this process is inappropriate soil management, a human activity documented in numerous studies, including those of Bennett (1929), Ellison (1948), Lal

(1997), and Bertoni and Lombardi Neto (2008). Water erosion affects most of the planet and is the result of rainfall and surface runoff, aggravated mainly by agricultural management systems (Zachar, 1982). Erosion alters the soil chemical, physical and biological properties, reducing soil fertility and, as a direct result, soil productivity (Pimentel et al., 1995; Lal, 2000, 2006; Morgan, 2005), which has caused concern among researchers in various fields about the losses and costs incurred.

Costs are calculated on the basis of *on-site* effects (losses within the productive unit) and *off-site* effects (damage caused beyond the agricultural property). In the United States, the annual cost of soil erosion for both on-site and off-site effects has been estimated at 44 billion dollars a year (Pimentel et al., 1995). In the European Union, the figure is 38 billion Euros a year (Montanarella, 2007). In Brazil, although soil conservation is a respected and well-established science, there are few studies on the costs of erosion, which are normally restricted to few soil types and regions (Marques et al., 1961; Silva et al., 1985; Sorrenson & Montoya, 1989; Derpsch et al., 1991; Marques, 1998; Rodrigues, 2005; Bertol et al., 2007; Sarcinelli et al., 2009).

3.10 WHY CONSERVE THE SOIL?

The classic problem of the sufficiency of natural resources and provision of food to the population continues, even nowadays, to be very worrying and is currently being approached as a food security issue. The relationship between natural resources and population was first mentioned in classical economics by Adam Smith in "The Wealth of Nations", (Smith, 2008), and later developed by Thomas Robert Malthus in his book "An Essay on the Principle of Population", (Malthus, 1999). Malthus based his argument on the fact that natural resources such as soil are limited and if conditions remain constant, the population tends to increase to the point at which there will not be enough food for everyone. In other words, while food production increases in arithmetic progression, population will grow in geometric progression. He concluded that production costs would not increase until all available land was being used. He also believed that arable land was of uniform quality.

David Ricardo introduced a few modifications into the Malthusian model in his book "On the Principles of Political Economy and Taxation" (Ricardo, 2006). He agreed that the amount of land was finite, but took its variability in terms of quality into account.

According to his theory, the best land would be used first, and then poorer quality land would be used. As a consequence, production costs would increase excessively, before reaching the limit of farming land. The point at which costs would begin to rise and the speed of this increase would depend on the quality of the land available and the population increase, i.e. the demand. As a result of changes brought about by the Industrial Revolution, these authors acknowledged the possibility of technological progress, but it was generally thought that this progress could at most delay the "fatal day", but not solve the problem of scarcity of natural resources.

The soil can be revitalized when nutritive substances run out, even if part of the soil is lost through erosion or destroyed in some other way. But if this degenerative process is not interrupted, it could irreversibly compromise the productive capabilities of farming land. Anthropogenic changes have often resulted in significant modifications of the soil productivity, either for better or worse and this has often obscured the dialog concerning soil conservation. There is an inability to differentiate periodic investments for current production from investments targeting alterations in the basic soil structure, soil conservation is an issue of religion (faith and ethics) and economics (business and investment-return comparison). Following the same reasoning, considered conservation to be a question of values: an investment to maintain the level of production, reduce the deterioration of productivity and increase productive potential. However, land cannot be considered in isolation. It only becomes productive when combined with work, capital, production materials and a management system.. A microeconomic analysis identifies a variety of combinations of production factors, although for many agricultural producers, these factors can be fixed.

Thus, soil conservation programs involve intertemporal, interspatial and interpersonal comparisons as well as differences between production levels and trends. Barlowe (1986) highlighted variations in future agricultural yields with and without investment in soil conservation. He stated that, if soil conservation is defined as the effort to modify a trend in soil productivity so as to make it better than it otherwise would be; this implies in a different distribution of investments and annual production than in cases in which the conservationist approach were not adopted. However, this analysis was carried out exclusively in terms of expected annual yield, and is valid only in these terms,

since it does not take account of the possibility of land valuation as a result of the stabilization of productivity. If the land market were perfect, future differences in productivity would be directly reflected in current land value.

One important reason for conserving the soil is to increase earnings. Due to the time lag between investment and production that conservation almost always involves, reliable comparisons should always be based on the current value and future costs. This in turn necessarily involves a rate of interest or depreciation, which is always difficult to correctly assess. The balance between current values of investment and future earnings is a measure of the profitability of the conservation program chosen and therefore, in the majority of cases, is an extremely important if not decisive factor. For many farmers, the rate of depreciation is a matter of intuition, not calculation and estimation. This explains the well-established fact that they prefer immediate returns, rather than future profits. But soil conservation, or the lack of it, is not based solely on profitability.

3.11 Impact of Soil erosion

1. Soil loss
2. Nutrient loss
3. Loss of organic matter
4. Drop in the soils chemical, physical and biological fertility
5. Damage to plantations
6. Yield drop
7. Production loss
8. Shrinkage of the available planting area
9. Sales reduction

3.12 CONSERVATION OF ENERGY

Meaning of Energy

Energy is defined as the capacity of a physical system to perform work. However, it's important to keep in mind that just because energy exists, that doesn't mean it's necessarily available to do work.

3.12.1 Types of Energy

1. Solar Energy
2. Wind Energy

3. Geothermal Energy
4. Hydrogen Energy
5. Tidal Energy
6. Wave Energy
7. Hydroelectric Energy
8. Biomass Energy

Energy is defined as the capacity of a physical system to perform work. In other words, It can be explained as the ability to perform or complete any type of work whether it is physical or mental activity.

We can also explain "energy" which includes physical movements like shifting something from one place to another, warming something or lighting something. Energy exists in numerous forms such as heat, kinetic or mechanical energy, light, potential energy, electrical or many other forms.

It can be better described by giving the below mentioned natural example of environment, it shows a chain cycle of converting different forms of energy into heat and power:

- Oil burns to make heat
- Heat boils water
- Water turns to steam
- Steam pressure turns a turbine
- Turbine turns an electric generator
- Generator produces electricity
- Electricity powers light bulbs
- Light bulbs give off light and heat

We utilize energy in different forms in our daily routine life and cannot think even about to survive without it. We use energy to light our homes and for street lighting as well, to be able to power machineries and equipments in factories, helps to cook our food, for playing music and operating televisions and many more every day regular uses.

It is the practice of reducing the quantity of energy used. It may be attained through efficient energy use; in this case, energy use is decreased at the same time getting a same outcome as a result, or by reduced consumption of energy services. It is one of the

easiest processes to help the globe by means of pollution in addition to make use of natural energy. It may result in increase of financial capital, better environmental results, national security, personal security and human comfort. Individuals and companies are called as direct consumers of energy may need to conserve energy so as to reduce energy expenses and promote economic security. Industrial and business class users may want to increase the efficiency and as a result, it maximizes their benefits as well. Energy conservation is the reduction or removal of unnecessary or unwanted energy use.

3.13 Importance of Energy Conservation

Energy conservation plays a significant role of lessening climate change. It helps the replacement of non-renewable resources with renewable energy. Energy conservation is often the most inexpensive solution to energy shortages, and it is more environmentally kind alternative to increased energy production. Since, we have limited quantity of non-renewable energy resources available on earth, it is very important to preserve energy from our current supply or to utilize renewable resources so that it is also available to our future generations. Energy conservation plays a very important role because utilization of non-renewable resources also impacts our environment. Specially, usage of fossil fuels supplies to air and water pollution such as carbon dioxide is produced when oil, coal and gas combust in power stations, heating systems, and engines of car.

As we all aware of that carbon dioxide works as a transparent layer in the atmosphere that is part of the cause to the global warming of the earth, or we can also name it as greenhouse effect. Global warming has its own consequences in our atmosphere. It has its deadly effects like spreading of different diseases, warmer waters and more chances of hurricanes, financial costs, polar ice melting, increased chances and intensity of heat waves. Ozone depletion is the reduction of the protection layer of ozone in the uppermost atmosphere by chemical pollution. Ozone layer is the protection line between earth and the ultraviolet rays emitted by the sun. People who have more exposure to UV radiation can have some health problems like DNA damage, skin cancer, aging and other problems related to skin.

There could be some possible issues that include a danger to human body health, impact on environment like rising sea levels, and major changes in vegetation growth methods. When coal is burned, it realises sulphur dioxide into the air and therefore, it

reacts with water and oxygen in the clouds and forms acid rain. Acid rain kills fish and trees and also damage limestone buildings and statutes. These types of global problems can be resolved. As per the data of United States calculated per year, we found that the average family's energy uses produces over 11,200 pounds of air pollutants. Therefore, every unit of kilowatt of electricity preserved diminishes the natural environment impact of energy use.

3.14 Methods of Energy Conservation

3.14.1 Get rid of incadescent light bulbs

The quality of light is close to ideal, however, they are incredible inefficient – only 10% of the electricity is converted into light while the rest ends up as heat. It's about time they are replaced with light bulbs that are more environmentally friendly.

3.14.2 Seal air leaks

Is your house uncomfortable when it gets cold outside despite the fact that all the heating is switched on? If you think it is due to poor insulation you may need to think again. Air leaks are often the main culprit in cold houses and sealing them can make a big difference.

3.14.3 Turn off electrical devices

This is a no-brainer. Turn off the lights when you leave a room. Don't let the TV run in the background if nobody is watching it. This also applies to all other electrical devices that you are not using.

3.14.4 Use energy-efficient windows, doors and skylights

Even though the window in an average house only covers about 5-10% of the outer surface, it is not uncommon that they are responsible for over 40% of the heat loss. A building's heating costs can therefore be drastically lowered if old windows are with poor energy ratings are replaced with energy-efficient alternatives. The same goes for doors and skylights as well. Reduced energy bills is not the only thing that people who have replaced old fenestration report of, but also increased indoor comfort.

3.14.5 Lower the room temperature

If you can handle it, lowering room temperature by only a degree or two, can result in big energy savings. The greater the difference between outdoor and indoor temperature is the more energy is used to maintain room temperature. You can always put on more

clothes. There are smarter and more comfortable ways of doing this. If you set your thermostat lower at night and at times when you are not home, you can still end up saving a lot of money. Get a programmable thermostat that allows you to do these things.

3.14.6 Get an energy audit

Before you start optimizing your house with ways to conserve energy you might want a consultation on where your house is *leaking* energy. This is exactly what an energy audit is. An expert performs a comprehensive home energy checkup: A series of tests to find out where your money is best spent to make your house more energy efficient.

Several methods/strategies have been suggested by conservationists, some of which are being followed in an attempt to conserve resources. The line of defence towards protecting our resources is waste reduction. Resource conservation basically means reduction of the amounts of solid waste that are generated besides reduction of overall resource consumption and utilization of recovered resources. Waste reduction is advocated as a principal means of conserving resources because a reduction in wastes implies more economical and efficient use of resources. Waste reduction can be achieved by redesigning industrial processes and by locating plants in such a way that residues of one plant can whenever and wherever possible be effectively used as raw materials by another industry. Waste rduction reduced environmental impacts and energy demands besidces conserving natural resources. Furhter it provides a check on the ever increasing costs of waste management.

Waste reduction can be achieved through several ways.

1. Increasing the durability of products
2. Utilizing material substitution
3. Recycling and
4. Marketability of industrial wastes

Increasing the durability of products means designing products for longer luse and designing them for easy and economical repair or manufacture. The replacement of unbreakable containers in the place of brittle/breakable containers is an example. Increasing the durability of the product otherwise called as ‘product life extension’ does not merely mean making it tougher or stronger. It involves designing problem and marketing problem. As pointed out by a Canadian research team: the design problem is

to ensure that replacement of worn parts is simple: the marketing problem is to make parts available". It further pointed out that if products are not durable, they should be repairable and durability meant either better materials or easily replaceable parts or both". Increase in durability will reduce wastes generated and promote preservation of our natural resources.

The process of material substitution as a mean of conserving resources depends on technology. The transition for example, requires one millionth of the materials needed to make the vacuum tube it replaces. Similarly commercial satellites, solid state electronics, microfilm facilities have reduced material requirements in communications industry. Aluminum is being extensively substituted for tin, particularly in the production of metal cans and containers. Similarly plastics are being used for insulation and anti-corrosive purposes where lead and zinc were originally used.

Substitution that would make possible more efficient energy use, will promote conservation of energy. Some have even suggested substitution of labour or capital for energy. However, a material substitution possibility is also limited by certain conditions. It is possible that all raw-materials including the substitutable materials will be depleted at the same time. Secondly, substitution may involve time lags. The time required for effective substitution is a crucial factor. Equally important is the interval required for diffusion of the substitute technology in all processes of the industry. It has been reported by an international review of this question that the total time required for effective substitution has been of the order of 25 to 30 years when diffusion time is included. Besides time factors, side effects of substitute materials in the form of more pollution also may pose problems. Aluminum smelters, for example, may involve more pollution than tin which they replace. Thus, while material substitution is an effective technique for resource conservation, it is limited by pollution impacts, time lag, and by the ability to manage the substitution process.

3.15 PRODUCT LIFE EXTENSION

This is a method by which the durability of the product is extended by deliberate design, so that the need for replacement would be postponed. It is a common practice that many modern producers design the goods for early disposal by the consumer to serve twin purpose of (a) boosting the sales and profits of the producing firm by encouraging

consumers to go in for replacement of their goods more rapidly. (b) Reflecting consumer's apparent desire for rapid changes of their goods for the sake of novelty.

By extending the life of the product, the requirement of resource materials can be appreciably brought down. However, the product life extension method has some disadvantages. It requires the customers to hold on the goods for a longer period. This will be possible only with substantial increase in the quality of the product to extend its durability. Otherwise, the product may become less suitable and the objective will be defeated. Thus, the product life extension has a potential role to play in conservation of resources.

3.16 RECYCLING

Recycling is the most popular method practiced today for conserving resources. Recycling simply means is a method of extending the life of a resource. It is the re-use of a given input or output. For example, form the effluents of distilleries manufacturing alcohol, methane is separated by a chemical process which is then recycled in the production process as fuel for boiler. The residual liquid of the effluent after separation of methane contains nitrogen, phosphate and potassium and is canalized in cane fields and has resulted in considerable increases in cane yield. Empirical evidence suggests that recovering and re-using industrial wastes is both technically feasible and economically attractive. A profit seeking company, however, will recycle a product only when its cost is lower than the use of the virgin material and this cost differential should be neither transitory nor cyclical. There are social costs and benefits associated with recycling, which private firms may not consider. The benefits of recycling essentially arise from the extension in the life of the recycled resource, the reduced pollution impact and the reduced demand for land for dumping. However, recycling is not a costless exercise. Hence, optimal level of recycling is said to be at the point at which extra costs of recycling outweighs extra benefits.

3.17 OPTIMUM RECYCLING

From the point of view of the private firm, the total cost has to be minimized, i.e., minimize,

$$C=TC_V+TC_R$$

Where TC_V and TC_R are total costs of virgin and recycled resources respectively, used in the production of X.

Total cost is minimized when,

$$MC_V+MC_R$$

From the social point of view, the objective into minimize,

$$S=TC_V+TC_R+ TEC_V+TEC_R$$

Where TEC_V+TEC_R are total external costs of pollution from using virgin materials and recycling process respectively.

This simplified model is illustrated in figure 3.2. In the figure, the horizontal axis shows recycling ratio. When r=1, there is complete recycling. When r=0, production is by original material only. TC_R will rise as r approaches 1. TC_V=0 when r=1 and TC_V will be positive r=0. TC_V will decrease with increase in recycling activities while TCR_R will rise with increase in recycling activities. Minimizing total social cost implies maximizing net social benefits. Gross social benefits are shown in the figure as the straight line bb^1 because they are assumed to be invariant with recycling ratio. Net social benefits are obviously the distance between total social cost curve and bb^1 line.

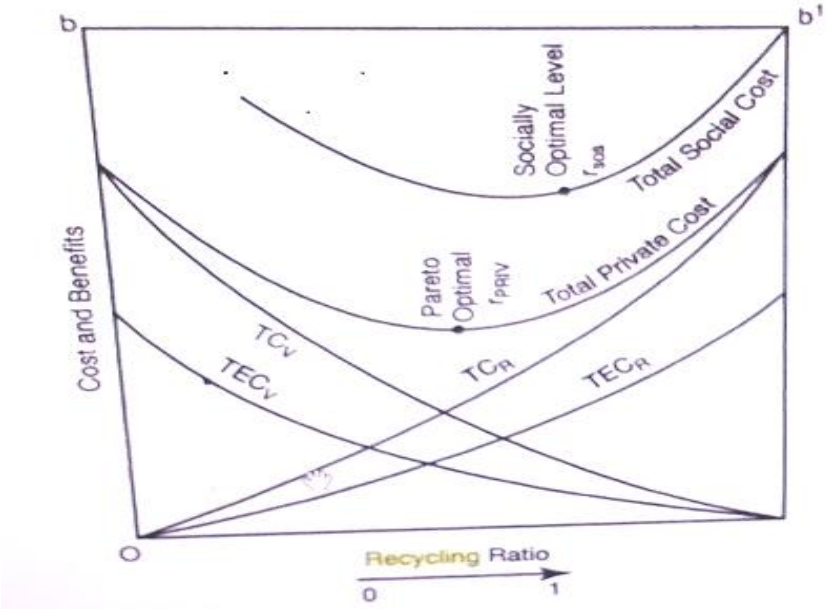


Fig: 3.1. Optimum Recycling

Total social cost is the sum of TC_V, TC_R, TEC_V and TEC_R. Thus, at E where total social costs are minimum, net social benefits are maximum. This is the socially optimum

recycling level R_{SOS}. It is to the right of private optimum recycling level R_{PRIV}. This implies that more recycling is socially desirable than what the private firms are willing to do. Such a difference between socially optimum recycling and private optimum recycling ($R_{SOS}>R_{PRIV}$) calls for fiscal intervention like a tax or subsidy to achieve the socially optimum level. However, it should be mentioned that the Y_{SOS} can be to the left of R_{PRIV} also. (i.e. $R_{SOS}<R_{PRIV}$). This implies that the level of recycling should be reduced. This may be because the pollution from recycling is a greater problem than the problem of disposal of waste from virgin resources.

Marketability of industrial wastes is also suggested as an alternative for recycling. The recycled wastes of an industry may find a market as an input in another industry. A number of companies are today re-suing their wastes in their own production process after treating them or they are marketing them. The Union Carbide in the USA, for example has been marketing some of its wastes since 1970s. The sugar industry today has found a permanent market for its by-product bagasse in the paper manufacturing industry. This strategy of marketing the wastes, can be compared to the market solution to externality problem, in which firms exploit the possibilities of earnings revenue while accounting for its external costs.

There are a number of other measures which supplement those already mentioned. Developing and using products requiring less material per unit of product (like smaller automobiles), substituting re-usable products for single use disposable products, increasing the number of times the times are re-used and reducing the number of units of products consumed per year per household are some of the measures in practice.

Conservation of renewable resources like forests, fisheries etc require a carefully and well-designed Government policy. Appropriate land use policy measure, a good forest policy and efficient use of alternative energy sources can to a great extent ameliorate misuse of renewable resources. What is required is a holistic approach to resource management. Renewable resources are mixed together. Land that grows trees for timber also provides habitat for wild life besides strong and filtering water. It may also contain deposits of precious metals. Hence resources cannot be managed with blinders; the damage inflicted on a resource have devastating effect on one or few more resources. Hence we need an integrated and holistic approach. When it comes to

resources, we must consider them all together. Only an integrated and holistic approach will lead to optimal use of resources.

3.18 WASTE REDUCTION

The problem relating to conservation of resources exhibit in two ways, one to consume or exploit the resources in a minimal way and the other is to avoid or reduce wastage in the process of production. If greater attention is paid to the latter, i.e., waste reduction, it will automatically ensure lesser exploitation of resources.

Waste reduction can be achieved by appropriately redesigning industrial processes, so that there will be technological efficiency in utilizing the resources and avoidance of waste to the minimum. Further, the waste of one industry can be used as the raw material of another industry. In such a case, marketability of industrial wastes should be explored in the place of recycling. Sugar industry can be cited as an excellent example of either using its own wastes or marketing the water materials. The bagasse of the sugar mills (which is a by-product) is sold to paper mills where bagasse is the main raw material for manufacture of papers. Similarly, the molasses, a by-product of the sugar mill is used in the distillery of the mill or sold to some other distilleries. The press-mud, another by- product is sold to farmers to be used as manure for their fields. The marketing of wastes offers solutions to the problem of externality and at the same time gives scope for earning revenue to the industry.

UNIT - IV

ENERGY ECONOMICS

4.1 Meaning of Energy

Energy is involved in all life cycles, and it is essential in agriculture as much as in all other productive activities. An elementary food chain already shows the need for energy: crops need energy From solar radiation to grow, harvesting needs energy from the human body in work, and cooking needs energy from biomass in a fire. The food, in its turn, provides the human body with energy.

Intensifying food production for higher output per hectare, and any other advancement in agricultural production, imply additional operations which all require energy. For instance: land preparation and cultivation, fertilising, irrigation, transport, and processing of crops. In order to support these operations, tools and equipment are used, the production of which also requires energy (in sawmills, metallurgical processes, workshops and factories, etc.).

Major changes in agriculture, like mechanisation and what is called the "green revolution", imply major changes with respect to energy. Mechanisation means a change of energy sources, and often a net increase of the use of energy. The green revolution has provided us with high yield varieties. But these could also be called low residue varieties (i.e. per unit of crop). And it is exactly the residue which matters as an energy source for large groups of rural populations.

Other sectors of rural life require energy as well. The provision of shelter, space heating, water lifting, and the construction of roads, schools and hospitals, are examples. Furthermore, social life needs energy for lighting, entertainment, communication, etc. We observe that development often implies additional energy, and also different forms of energy, like electricity.

All the sources of energy, currently available for harnessing can be linked to two fundamental forces in nature-gravitational and nuclear. Nuclear fusion is the sources of solar energy. The driving force for much of the energy is consumed on earth today. Renewability or non-renewability of a solar driven process is distinguished based on the energy storage or cycling time involved. Renewable resources have a cycling time less

than 100 years, while for non-renewable resources; it is greater than a million years. The depletable resources are fossil fuels, which are non - renewable since the rate of their utilisation far exceeds the rate at which they are formed. Examples of renewable resources are hydro energy, solar energy, wind, biomass, and energy from wastes (such as biogas, agro-wastes, etc.). The renewable solar energy is subdivided into direct and indirect types. Sunlight used directly can produce electricity, heat or derive a chemical reaction. It is used indirectly when it drives other processes, biological - chemical or climatic - mechanical, which in turn are used as sources of energy. The energy sources can be classified in a number of ways based on the nature of their transaction, as commercial and noncommercial sources of energy . All energy resources, particularly the commercial ones, are natural. Coal, oil and nuclear sources constitute commercial sources, while firewood, biomass and animal dung constitute non- commercial sources. Also, the energy sources are classified based on animate and inanimate characteristics. Energy sources could also be classified as exhaustible/depletable or non - depletable /renewable resources. The distinguishing feature of an exhaustible resource is that, it gets exhausted when used as an input of a production process, and at the same time, its undisturbed role of growth is nil. That is, the temporal services provided by a given stock of an exhaustible resource are finite. Further, based on conventionality in deriving energy, energy sources could be classified as conventional (coal, oil, hydro, nuclear, etc.) and non - conventional (solar, wind, tidal, geothermal, biogas, etc.) sources.

They are also classified as primary or secondary types - coal, firewood, etc., being primary sources and electricity, a secondary source. Energy in its primary form can be of different kinds. The main types are Chemical (fossil fuels- coal, oil, natural gas, peat; biomass - wood, agricultural residues, etc.),Potential (water at a certain height),Kinetic (wind, waves), Radiation (sun), Heat (geothermal reservoirs, ocean thermal reservoirs) and Nuclear (uranium). The primary form of energy must generally be converted into secondary or final forms of energy before it can be used. For instance, the potential energy of a waterfall (primary energy) is converted into electricity (secondary energy), which is transmitted and transformed to supply (final) energy to a factory, where it is converted into mechanical energy (useful energy) for productive operations.

Important types of secondary energy are electricity and mechanical energy. But chemical energy is also important as a secondary energy, for instance, in the form of refined oil products. Final energy is the energy that reaches the consumer. This can be electricity at a suitable voltage, or chemical energy in kerosene or batteries. The consumer, finally, uses certain equipment to convert the final energy he buys, into useful energy for one of his end use activities, e.g., irrigation, transport, cooking, etc. Most of the energy sources are substitutable to each other due to the fact that some form of energy can be converted to other - such as coal to electricity, use of photo electricity to drive a chemical reaction, wind energy to pump and store water that could be used to produce electricity when required, or solid biomass to produce liquid or gaseous fuels of higher calorific value. All forms are ultimately converted into heat. This gives rise to the inter-fuel substitution process with which an economy can substitute its abundantly available resources to the scarcely endowed one.

About 70% of India's energy generation capacity is from fossil fuels, with coal accounting for 40% of India's total energy consumption followed by crude oil and natural gas at 24% and 6% respectively. India is largely dependent on fossil fuel imports to meet its energy demands — by 2030, India's dependence on energy imports is expected to exceed 53% of the country's total energy consumption. In 2009-10, the country imported 159.26 million tonnes of crude oil which amount to 80% of its domestic crude oil consumption and 31% of the country's total imports are oil imports. The growth of electricity generation in India has been hindered by domestic coal shortages and as a consequence, India's coal imports for electricity generation increased by 18% in 2010. Due to rapid economic expansion, India has one of the world's fastest growing energy markets and is expected to be the second-largest contributor to the increase in global energy demand by 2035, accounting for 18% of the rise in global energy consumption. Given India's growing energy demands and limited domestic fossil fuel reserves, the country has ambitious plans to expand its renewable and nuclear power industries. India has the world's fifth largest wind power market and plans to add about 20GW of solar power capacity by 2022. India also envisages to increase the contribution of nuclear power to overall electricity generation capacity from 4.2% to 9% within 25 years. The

country has five nuclear reactors under construction (third highest in the world) and plans to construct 18 additional nuclear reactors (second highest in the world) by 2025.

4.2 Types of Energy

1. Potential Energy
2. Kinetic Energy

Potential Energy: Potential energy is stored energy and the energy of position (gravitational). It exists in various forms.

Kinetic Energy: Kinetic energy is energy in motion- the motion of waves, electrons, atoms, molecules and substances. It exists in various forms.

Various Forms of Energy:

Chemical Energy: Chemical energy is the energy stored in the bonds of atoms and molecules. Biomass, petroleum, natural gas, propane and coal are examples of stored chemical energy. **Nuclear Energy:** Nuclear energy is the energy stored in the nucleus of an atom - the energy that holds the nucleus together. The nucleus of a uranium atom is an example of nuclear energy. **Stored Mechanical Energy**: Stored mechanical energy is energy stored in objects by the application of a force. Compressed springs and stretched rubber bands are examples of stored mechanical energy.

Gravitational Energy: Gravitational energy is the energy of place or position. Water in a reservoir behind a hydropower dam is an example of gravitational energy. When the water is released to spin turbines, it becomes rotational energy.

Radiant Energy: Radiant energy is electromagnetic energy that travels in transverse waves. Radiant energy includes visible light, x-rays, gamma rays and radio waves. Solar energy is an example of radiant energy.

Thermal Energy: Thermal energy (or heat) is the internal energy in substances- the vibration and movement of atoms and molecules within substances. Geothermal energy is an example of thermal energy.

Electrical Energy: Electrical energy is the movement of electrons. Lightning and electricity are examples of electrical energy.

Motion: The movement of objects or substances from one place to another is motion. Wind and hydropower are examples of motion.

Sound: Sound is the movement of energy through substances in longitudinal (compression/rarefaction) waves.

Light Energy: Light energy is a type of wave motion. That is, light is a form of energy caused by light waves. It enables us to see, as objects are only visible when they reflect light into our eyes.

Nuclear Energy: Nuclear energy is a controversial energy source. It is not a renewable energy source, but because it is a technology not based on fossil fuels many people think nuclear power plants could play an important role in reducing carbon emissions and battling climate change. However, many others feel the risk of accidents and the issues of storing nuclear waste for thousands of years are too significant to warrant the development of this energy source.

4.3 CLASSIFICATION OF ENERGY RESOURCES

The various sources of energy can be conveniently grouped as

Commercial primary energy resources: Non-renewable sources of energy or conventional sources of energy are being accumulated in nature for a very long time and can't be replaced if exhausted. Nature gifted resources which are consumed can't be replaced. Eg: coal, petroleum, natural gas, thermal power, hydro power and nuclear power are the main conventional sources of energy.

Renewable sources of energy: Energy sources, which are continuously and freely produced in the nature and are not exhaustible, are known as the renewable sources of energy. Eg: solar energy, biomass and wood energy, geo thermal energy, wind energy, tidal energy and ocean energy. But main attention has to be directed to the following sources of renewable namely, a) solar photovoltaic, b) wind, and c) hydrogen fuel cell.

New sources of energy: The new sources of energy are available for local exploitation. In many cases, autonomous and small power plants can be built to avoid transmission losses. Most prominent new sources of energy are tidal energy, ocean waves, OTEC, peat, tar sand, oil shales, coal tar, geo thermal energy, draught animals, agricultural residues etc., The total energy production in India is 14559×1015 joules. 93% of India's requirement of commercial energy is being met by fossil fuels, with coal contributing 56%, and oil and natural gas contributing 37%. Water power and nuclear power are contributing only 7% of total energy production. Comparing the total energy

production in India from commercial sources with that of world, it is only 3.5% of total world production.

4.4 RENEWABLE AND NONRENEWABLE SOURCE OF ENERGY

Renewable resources are resources that are replenished by the environment over relatively short periods of time. This type of resource is much more desirable to use because often a resource renews so fast that it will have regenerated by the time you've used it up. Think of this like the ice cube maker in your refrigerator. As you take some ice out, more ice gets made. If you take a lot of ice out, it takes a little more time to refill the bin but not a very long time at all. Even if you completely emptied the entire ice cube bin, it would probably only take a few hours to 'renew' and refill that ice bin for you. Renewable resources in the natural environment work the same way.

Solar energy is one such resource because the sun shines all the time. Imagine trying to harness all of the sun's energy before it ran out! Wind energy is another renewable resource. You can't stop the wind from blowing any more than you can stop the sun from shining, which makes it easy to 'renew.' Any plants that are grown for use in food and manufactured products are also renewable resources. Trees used for timber, cotton used for clothes, and food crops, such as corn and wheat, can all be replanted and regrown after the harvest is collected. Animals are also considered a renewable resource because, like plants, you can breed them to make more. Livestock, like cows, pigs and chickens, all fall into this category. Fish are also considered renewable, but this one is a bit trickier because even though some fish are actually farmed for production, much of what we eat comes from wild stocks in lakes and oceans. These wild populations are in a delicate balance, and if that balance is upset by overfishing, that population may die out.

Water is also sometimes considered a renewable resource. You can't really 'use up' water, but you also can't make more of it. There is a limited supply of water on Earth, and it cycles through the planet in various forms - as a liquid (our oceans), a solid (our polar ice caps and glaciers) and a gas (as clouds and water vapor). Liquid water can be used to generate hydroelectric power, which we get from water flowing through dams. This is considered a renewable resource because we don't actually take the water out of the system to get electricity. Like sunshine and wind, we simply sit back and let the resource do all the work. For example,

1. Solar Energy
2. Wind energy
3. Tidal energy
4. Hydro power
5. Geothermal energy
6. Biofuels

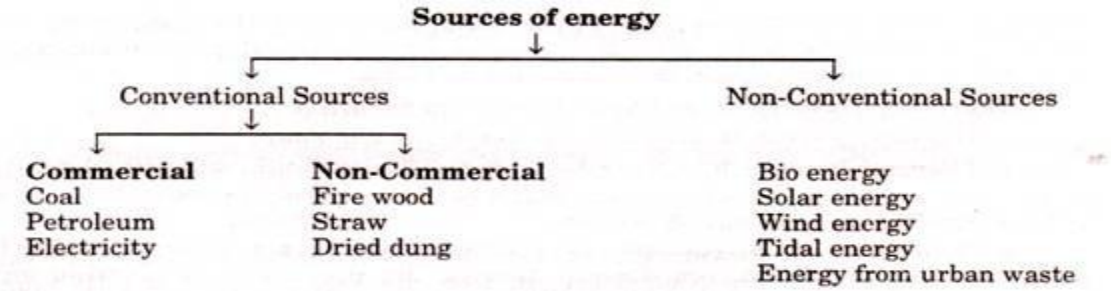
Nonrenewable resources: The resources which are non-renewable are called as Non-Renewable sources. The Non-Renewable resources do not replenish and cannot be renewed. It took thousands of years of time to form the non-renewable resources which exist inside the earth in the form of coal, fossil fuels, etc. For example,

1. Coal
2. Mineral Ores
3. Metal Ores
4. Crude Oil
5. Nuclear Energy

4.5 CONVENTIONAL AND NON-CONVENTIONAL SOURCES OF ENERGY

Energy is one of the most important components of economic infrastructure. It is the basic input required to sustain economic growth. There is direct relation between the level of economic development and per capita energy consumption. Simply speaking more developed a country, higher is the per capita consumption of energy and vice-versa. India's per capita consumption of energy is only one eighth of global average. This indicates that our country has low rate of per capita consumption of energy as compared to developed countries.

Two main Sources of Energy



4.6 CONVENTIONAL SOURCES OF ENERGY

These sources of energy are also called non renewable sources. These sources of energy are in limited quantity except hydro-electric power. These are further classified as commercial energy and non-commercial energy.

4.6.1 Commercial Energy Sources

These are coal, petroleum and electricity. These are called commercial energy because they have a price and consumer has to pay the price to purchase them.

(a) Coal and Lignite

Coal is the major source of energy. Coal deposits in India are 148790 million tonnes. Total lignite reserves found at Neyveli are 3300 million tonnes. In 1950-51, annual production of coal was 32 million tonnes. In 2005-06, annual production of coal was 343 million tonnes.

Lignite production was 20.44 million tonnes in 2005-06. According to an estimate, coal reserves in India would last about 130 years. India is now the fourth largest coal producing country in the world. Coal deposits are mainly found in Orissa, Bihar, Bengal and Madhya Pradesh. It provides employment to 7 lakh workers.

(b) Oil and Natural Gas

In these days oil is considered as the most important source of energy in India and the world. It is widely used in automobiles, trains, planes and ships etc. In India it is found in upper Assam, Mumbai High and in Gujarat. The resources of oil are small in India.

In 1950-51, the total production of oil in India was 0.3 million tonnes. It increased to 32.4 million tonnes in 2000-01. Despite tremendous increase in oil production. India still imports 70% of has oil requirements from abroad. In 1951, there was only one oil refinery in Assam. After independence 13 such refineries were set up in public sector and their refining capacity was 604 lakh tonnes. After implementation of economic reforms, private refineries are also engaged in oil refining. As per current rate of consumption, oil reserves in India may last about 20 to 25 years.

Natural gas has been the most important source of energy since last two decades. It can be produced in two ways:

i. With petroleum products as associated gas.

ii. Free gas obtained from gas fields in Assam, Gujarat and Andhra Pradesh.

It is used in fertilizer and petro-chemical plants and gas based thermal power plants. Total production of natural gas was 31.96 billion cubic metre in 2003-04.

(c) Electricity

Electricity is the common and popular source of energy. It is used in commercial and domestic purposes. It is used for lighting, cooking, air conditioning and working of electrical appliances like T.V., fridge and washing machine.

In 2000-01 agriculture sector consumed 26.8%, industrial sector 34.6% and 24% of electricity was used for domestic purposes and 7% was used for commercial purpose. Railways consumed 2.6% and miscellaneous consumption was 5.6%.

There are three main sources of power generation

1. Thermal Power
2. Hydro-electric power
3. Nuclear Power

1. Thermal Power

It is generated in India at various power stations with the help of coal and oil. It has been a major source of electric power. In 2004-05, its share in total installed capacity was 70 percent.

2. Hydro electric Power

It is produced by constructing dams over overflowing rivers. For example Bhakra Nangal Project, Damodor Valley Project and Hirakund Project etc. In 1950-51, installed capacity of hydro-electricity was 587.4 MW and in 2004-05, it was 19600 MW.

3. Nuclear Power

India has also developed nuclear power. Nuclear Power plants use uranium as fuel. This fuel is cheaper than coal. India has nuclear power plants at Tarapur, Kota (Rajasthan) Kalapakam (Chennai) Naroura (UP). Its supply accounts for only 3 percent of the total installed capacity.

4.7 NON-COMMERCIAL ENERGY SOURCES

These sources include fuel wood, straw and dried dung. These are commonly used in rural India. According to an estimate, the total availability of fuel wood in India was

only 50 million tonnes a year. It is less than 50% of the total requirements. In coming years, there would be shortage of fire wood. Agricultural wastes like straw are used as fuel for cooking purposes. According to one estimate agricultural waste used for fuel might be 65 million tonnes. Animal dung when dried is also used for cooking purposes. Total animal dung production is 324 million tonnes out of which 73 million tonnes are used as fuel for cooking purposes. The straw and dung can be used as valuable organic manure for increasing fertility of soil and in turn productivity.

4.8 Non-Conventional Sources of Energy:

Besides conventional sources of energy there are non-conventional sources of energy. These are also called renewable sources of energy. Examples are Bio energy, solar energy, wind energy and tidal energy. Govt. of India has established a separate department under the Ministry of Energy called as the Department of Non-conventional Energy Sources for effective exploitation of non-conventional energy.

4.9 The various sources are given below:

4.9.1 Solar Energy

Energy produced through the sunlight is called solar energy. Under this programme, solar photovoltaic cells are exposed to sunlight and in the form of electricity are produced. Photovoltaic cells are those which convert sun light energy into electricity. In year 1999-2000, 975 villages were illuminated through solar energy. Under Solar Thermal Programme, solar energy is directly obtained. Sunlight is converted into thermal power. Solar energy is used for cooking, hot water and distillation of water etc.

4.9.2 Wind Energy

This type of energy can be produced by harnessing wind power. It is used for operating water pumps for irrigation purposes. Approximately 2756 wind pumps were set up for this purpose. In seven states, wind power operated power houses were installed and their installed capacity was 1000 MW. India has second position in wind power energy generation.

4.9.3 Tidal Energy

Energy produced by exploiting the tidal waves of the sea is called tidal energy. Due to the absence of cost effective technology, this source has not yet been tapped.

4.9.4 Bio Energy

This type of energy is obtained from organic matter. It has two kinds.

(i) Bio Gas

Bio Gas is obtained from Gobar Gas Plant by putting cow dung into the plant. Besides producing gas this plant converts gobar into manure. It can be used for cooking, lighting and generation of electricity. 26.5 lakh bio gas plants had been established by the year 2003-04. They produce more than 225 lakh tonnes of manure. About 1828 large community bio gas plants have been established in the country.

(ii) Bio Mass

It is also of a source of producing energy through plants and trees. The purpose of bio mass programme is to encourage afforestation for energy. So that fuel for the generation of energy based on gas technique and fodder for the cattle could be obtained, 56 MW capacity for the generation of bio mass energy has been installed.

4.9.5 Energy from Urban Waste

Urban waste poses a big problem for its disposal. Now it can be used for generation of power. In Timarpur (Delhi) a power Ration of 3.75 capacity has been set up to generate energy from the garbage.

4.10 DIRECT AND INDIRECT ENERGY

Direct Energy is a retail supplier of electricity and natural gas (depending on your location), and your local distributor is a regulated entity that delivers electricity or natural gas to your home. Direct Energy is able to purchase the electricity or natural gas on the competitive market and sell it to customers. Your local distributor continues to deliver that electricity or natural gas to your home.

It is critical to protect the environment so as to reduce the destruction of eco-systems caused by a myriad of anthropogenic activities. It is more of a moral obligation for humans to protect the environment from pollution and other activities that lead to environmental degradation. Importantly, environmental degradation is detrimental since it threatens the long-term health of the animals, humans and plants. Air and water pollution, global warming, smog, acid rain, deforestation, wildfires are just few of the environmental issues that we are facing right now. It is everyone's responsibility to take care of the environment to make this planet a wonderful place to live. One does not

need to put lot of money to go green but simple changes in daily lifestyle is all what is required to reduce your carbon footprint on the environment.

The unsustainable "footprint" of economic activity would first lead to sharply rising input prices, and ultimately to the depletion of crucial inputs, pushing substitution costs to unaffordably high levels. This could have significant impacts on growth, both in developed but even more so in developing countries. Even wars for access to limited resources (water, oil?) could be expected. This type of "doomsday" standpoint achieved particular prominence with the publication by the Club of Rome of The Limits to Growth (Meadows et al. 1972). They predicted that if the then current trends in population, industrialisation, pollution, food production and resource depletion were to continue unchanged, then within the following one hundred years, "the most probable result will be a rather sudden and uncontrollable decline in both population and industrial capacity."

Brundtland et al. in Our common future (1987), while not making dramatic predictions of this sort, highlighted the implications for world energy consumption of the combination of a rising world population with the need to achieve much higher living standards of the populations of poorer countries. The recent rise in oil prices has revived fears of looming shortages,1 even if it is generally accepted that part of the price rise reflected a perceived increase in the risk of supply disruptions due to heightened political tension in the Middle East and other parts of the world. A period of sustained, rapid commodity price increases would tend to strengthen the arguments of those who argue that our societies are developing along fundamentally unsustainable paths. Others take a more optimistic view. While acknowledging that natural resources such as fossil fuels and minerals are indeed finite, they foresee considerable potential for society to adapt to possible future shortages through innovation and technical progress. This view rests in part on historic evidence of huge improvements in the efficiency of resource use: for example, the efficiency by which the energy in coal is converted to steam has increased over time by a factor of 25.

Dasgupta and Heal (1979) show that, in general, markets will allocate non-renewable resources efficiently over time only under quite restrictive conditions. To date, the targets of environmental policy-makers, perhaps to the surprise of some, tend to support the optimists: preserving non-renewable resources has not been the main driver

of environmental policy. In fact, contrary to what one might expect, the most pressing environmental issues are human health and environmental problems caused by overuse (in terms of overstretching the carrying and recovery capacity) of renewable resources: air and water pollution, climate change and biodiversity loss. As argued below, this apparent paradox of relative shortage in renewable resources and relative abundance of non-renewable resources can be explained in terms of the presence or absence of enforceable property rights. The problem of climate change is a particularly forceful example of the contrast between relative abundance of non-renewable resources and relative shortage of renewable ones.

According to the Intergovernmental Panel on Climate Change, increased atmospheric concentrations of greenhouse gases – mainly due to emissions of carbon dioxide from the burning of fossil fuels – are likely to be warming the earth's atmosphere, thus affecting the climate. The likely impacts include more extreme weather conditions, with an increased risk of heat waves, droughts and floods and their associated damages. In the longer term, global warming could cause – besides a general rise in sea levels - severe shocks such as shutting down or substantially weakening the Gulf Stream. This would give much of Europe a less temperate climate, with significant impacts for economic activity. Yet cumulative emissions of carbon dioxide from the middle of the 19th century to date – that are already judged to be causing climate change – result from the burning of no more than 6 per cent of the world's estimated total fossil fuel resources. Thus, the problem for environmental policy is not that we are running out of a non-renewable resource – fossil fuel – but that we are overstretching the capacity of the earth's atmosphere, a renewable resource.

UNIT – V

ENVIRONMENTAL PROBLEMS IN INDIA

5.1 AIR POLLUTION

"The air nimbly and sweetly recommends itself unto our gentle senses" - So wrote William Shakespeare in Macbeth. The stale of atmosphere today does not inspire a poet of comparable skill, to express a similar sentiment. Air constitutes about eighty per cent of the man's daily intake by weight- We breath about 2,200 times a day, inhaling around sixteen kg. of air. It is therefore essential that we know more about the atmosphere and the ways in which it is polluted.

5.2 Structure of the Atmosphere

Atmosphere is the life blanket of earth, the essential ingredient for all living things. Air covers every part of the two hundred million square miles of the earth's surface. The atmosphere is not just the air breathed by people, animals and plants. It is also a gaseous substance enveloping the earth, protecting it from abrupt changes in temperature and protecting all living beings from harmful solar and cosmic radiation. The direct and indirect influences of the atmosphere on man are varied.

The atmosphere consists of:

1. The troposphere which contains eighty per cent of the atmospheric mass and water vapour: the weather phenomena develop in it;
2. Above the troposphere is the stratosphere where the greatest concentration of ozone is observed. The ozone absorbs most of the solar ultra-violet radiation and protects life from its harmful effects.
3. Above the stratosphere is the ionosphere containing highly ionised gas molecules. This layer protects the biosphere from the harmful effects of cosmic radiation and influences the reflection and absorption of radio waves.
4. The exosphere is located above the ionosphere.

5.3 Gas Composition

Atmosphere is the best example of an infinite and free resource. Upto 250 kms, the atmosphere comprises of the following gases.

Nitrogen	-	78.09%
Oxygen	-	20.95%
Argon	-	0.93%
Carbon dioxide	-	0.03%

Besides these there are small quantities of neon, helium, krypton, xenon, hydrogen and ozone. The amount of air in the atmosphere is estimated to be six quadrillion tons.

(A quadrillion is one followed by twenty-five zeros in USA and France and by twenty four zeros in UK and Germany.) It is constantly in movement about the earth's surface in both horizontal and vertical directions. According to Soviet Space Research, the principal component of the atmosphere at a height of 250 to 300 kms is atomic oxygen. Even higher, at a height of 500 to 600 kms, the atmosphere becomes a mixture of helium and hydrogen and its very outer layer consists of atomic hydrogen. Besides, this, atmosphere always contains a certain amount of water vapour.

5.4 Air Pollution

For a long time the problem of air pollution in the cities was chiefly connected with coal burning in heating systems which emitted smoke ashes and sulphurous gas. Today industrial enterprises and automobiles are the primary sources of atmospheric pollution. Increasing industrialisation and urbanisation have created growing demands to use the atmosphere, as a waste disposal medium. Thus the accumulation of waste gases and particles from combustion, production and other economic activities exceeds the natural dispersion capacity of the atmosphere. When air movements are unable to disperse wastes at the rate they enter the atmosphere, air quality deteriorates and the seemingly infinite supply of clean air diminishes. Thus air is polluted.

Definition

Air pollution is defined by WHO as "the presence in the air of Solvent usage substances put thereby acts of man in concentrations sufficient to interfere with the comfort, safety, or health of man or with the full use or enjoyment of his property. The presence of contaminants in the atmosphere is considered to be in sufficient quantities and duration, to cause them to be injurious to human health, animal and plant life, and reduce welfare in general.

5.5 Sources and Composition of Air Pollutants

A distinction can be drawn between natural and artificial sources of-atmospheric pollution. Natural pollution of the atmosphere occurs when volcanoes erupt, rock is weathered, dust storms take place, forest fires occur, result of lightning and sea salt is washed ashore. Artificial pollution of the atmosphere is characteristic mostly of cities and industrial districts. Cities and suburbs contain numerous industrial enterprises and automobiles which pollute the atmosphere and negatively influence the local climate. Today industrial enterprises and automobiles are the primary sources of atmospheric pollution / Industry pollutes the atmosphere by emissions of harmful gases and industrial dust. (The chemical composition of emissions into the atmosphere is different depending on the kind of fuel, of raw materials, technology etc. The table 5.1 is a classification of Air Pollution sources and emissions.

Table 5.1 Classification of Air Pollution Sources and Emissions

Type	Category	Examples	Important Pollutants
Combustion	Fuel burning	Domestic burning, thermal power plant	Sulphur and nitrogen oxide
	Transportation	cars, trucks, aero planes, and railways	carbon-monoxide, nitrogen oxide, lead, smoke
	Refuse burning	open burning dumps	fly ash and particulates
Manufacturing processes	chemical plants	petroleum refineries, fertilizers, cement, paper mills, ceramics	hydrogen sulphide, sulphur oxide, fluorides, and dusts
	metallurgical plants	aluminum refineries and steel plants	Metal fumes (lead and zinc) fluorides and particulates
	waste recovery	scrap metal yards	smoke, soot, metal fumes
Agricultural activities	crop spraying	pest and weed control	organic phosphates chlorinated hydrocarbons, lead
	field burning	burning of refuse, firewood and dry cattle dung	smoke, fly ash, soot, sulphur oxides, particulates and organic vapours
Solvent usage	spray painting solvent extractions, inks solvent cleaning	Furniture and appliances finishing, printing and chemical separations. Dry-cleaning, degreasing	hydro carbons and other organic vapours
Nuclear energy programmes	Fuel fabrication Ore-preparation	gaseous diffusion crushing, grinding and screening	fluorides uranium and beryllium dust and other particulates, argon 4.1, iodine 131.
	Nuclear device testing	Bomb explosions	radioactive fallout, Sr. 90, CS-137, C-14 etc.

Source: "Making it Unfit to Breathe?" by P.K. Zutshi in Science Today, October 1970, Pp.28-36.

Specifically some of the major pollutants of atmosphere are sulphur oxides, nitrogen oxides, hydrocarbons, carbon monoxide, particulates, photochemical smog. We may broadly classify them as gaseous pollutants and pollutants and aerosols.

Gaseous Pollutants

Sulphur Dioxide: This colourless suffocating gas is produced by the burning of coal, gas or fuel oil both for domestic and industrial purposes. It is a gas that is poisonous to both plants and animals. Besides petroleum industry, oil, refining and sulphuric acid, it is produced mostly by power plants which burn coal to generate electricity. A large power plant may bum 10,000 tonnes of coal a day. If this coal is contaminated with three per cent sulphur, some nine hundred tons of sulphur dioxide per day will be discharged.

5.6 Effects

Air-borne, for long periods, sulphur dioxide gradually reacts with oxygen and water vapour in the air to form sulphuric acid (H_2SO_4). Thus nine hundred tonnes of SO_2 from one day's operation of a single large power plant become some one thousand and five hundred tonnes of sulphuric acid by the addition of oxygen and hydrogen to the molecule. The sulphuric acid is diluted by rainfall but even the rain is said to be 10 to 100 times more acidic than normal. In a similar way nitrogen oxides form nitric acid. Rain water containing such acids is called acid rain. The effects of acid rain are numerous. It increases the corrosion rate of all metal structures such as bridges. The most serious long term effect of acid rain is a gradual lowering of the pH^1 of water and soil. This can lead to gross alteration of aquatic eco-systems and a greatly increased rate of leaching. Yet another striking effect of acid rain is the dissolving of limestone and marble. In the last few decades, many statues and monuments have been eroded.

The effects of acid rain are observed hundreds of miles away from pollution sources. Sulphur dioxide originating in England has caused extensive acid rain damage to lake and stream eco-systems in Sweden. Besides these, sulphur dioxide emissions cause suffocation, irritation of throat and eyes and respiratory diseases.

Nitrogen Oxides

Nitric oxides and Nitrogen oxides are the dangerous nitrogen oxides. The oxides are formed by the combination of atmospheric nitrogen and oxygen during any form of combustion. Nitrogen oxides are mainly emitted by acid manufacturers, automobile

exhaust and explosive industry. Besides resulting in acid rains and [be associated damages mentioned already, nitrogen oxides also have other adverse effects. Oxides of nitrogen damage crops (namely leaf abscission) and affects at. als. Health hazards of nitrogen oxides are bronchitis and oedema of lungs.

Carbon monoxide is a colourless and odourless gas produced by the inefficient combustion of carbon fuels. In combustion carbon dioxide and water vapour are formed. But when combustion is incomplete, carbon does not have enough oxygen to combine with and forms carbon monoxide. Although motor vehicle's are the principal sources of carbon monoxide emissions, mines and blast furnaces also emit carbon monoxide.

Carbon monoxide can pose a serious health problem. It is highly toxic at significant levels of concentration and can cause decreased human efficiency in low but chronic doses. The principal effect of carbon monoxide on human beings and animals is its interference with transfer of oxygen in the body.

Hydro Carbons

Hydro carbons are organic gases composed of carbon and hydrogen. Inefficient combustion in motor vehicles is the major source of hydro carbons. Hydro carbons, by themselves are non-toxic gases and do not pose immediate threat to health unless absorbed in extreme concentration. The major problem with hydro carbons is their ability to react with nitrogen oxide through photo-chemical reaction in sunlight to produce "smog". Smog can result in serious sight and respiration problems. Thus hydro carbons may be cancer producing (carcinogenic). It retards plant growth and causes abnormal leaf and bud development.

Ozone

Ozone is present in minute traces in the atmosphere and serves as a natural filter for absorption of the short wave length ultra violet solar radiation which is harmful to life. Ozone is a highly reactive compound. It is produced mainly from oxygen containing molecules such as SO_2, NO_2 and aldehyde on absorption of ultra violet radiations. Nitrogen dioxide breaks into nitric oxide and atomic oxygen by the action of sun light. This atomic oxygen combines with an oxygen molecule to form ozone. Certain substances like chlorofluoro carbons (CFCs), nitrous oxides and nitrogen oxides are known to upset the balance between production and destruction of ozone, thus depleting

the ozone layer above earth's surface. One of the impacts of depletion of ozone layer is reinforcement of green house effect of carbon dioxide. The other major impact of ozone depletion would be increase in ultra violet radiation. It is estimated that a one per cent reduction in upper stratospheric ozone could lead to an increase of about two per cent in ultra violet (UV-B) radiation which can kill micro organisms outright and destroy cells in plants and animals. It is said to result in skin cancer on human beings.

On the other hand, in concentrations above normal ozone is poisonous and smelly. Ozone discolours leaves, trees and shrubs. It damages and fades textiles and reduce athletic performance. It hastens cracking of rubber. Ozone irritates eyes, nose, throat and induces coughing.

Aerosols

The atmospheric pollution that are classified as aerosols are: smog, smoke, fumes, mists (fog), dusts and particulates.

Smog

This is a synchronym of two words- smokes and fog. Smog can be of two types - photo-chemical or coal induced. Photo- chemical smog is caused by incomplete combustion in the automobiles. The incompletely burnt gasoline molecules releases hydro carbons and nitrogen oxides. The interaction of these in the presence of sunlight in the atmosphere form many compounds that are irritating and toxic to humans, animals and plants. Smog resulting thus by the interactions between nitrogen oxides and hydro carbons in the presence of sunlight, is seen as a brownish haze. Its main constituents are nitrogen oxides, peroxy nitrates, hydro carbons, carbon monoxide, ozone.

The fog from burning coal covers urban areas at nights or on cold days when the temperature is below 10°C. This fog consists of smoke, sulphur compounds and fly ash.
Fumes are mostly composed of solid particles - the common ones being metals, metallic oxides and chlorides. Chemical industries, paint, metal and rubber industries mainly emit fumes. Mists consist of liquid particles. Steam, fog and sulphur trioxide are some examples of mists.

Particulates

Particulate matter suspended in the air is one of the most noticeable of air pollutants and consists of chemically stable substances such as dust, soot, ash and smoke.

These pollutants are classified as primary pollutants, because they do not change their form after entering the atmosphere. Primary pollutants are dispersed and diffused by natural air movements but their structure or composition remains unaltered. Extensive industrial use of coal in the steel and electrical power industries, are the major sources of particulates. Besides, industrial fuels, automobiles, building materials, smelters also disperse particulates into the atmosphere. These tiny particles reduce visibility, damage property and carry poisonous materials into the lungs.

Consequences of Deteriorating Air Quality

Deteriorating air quality has important consequences on human beings, animals, flora and fauna, properties and climate.

5.7 Effects of Air Pollutants on Human Health

Determining effects of air pollution on human health is the chief concern of this section. In the recent past there has been a dramatic rise in the respiratory disease. This is because of the air pollutants that attack human health primarily through the respiratory-system.

Toxic substances enter the human body by ingestion, by absorption through the skin or eyes, by means of a puncture or injection or by inhaling dust or gas. Air pollutants enter the body through respiratory system. In general four factors influence the effect of a toxicant on an individual toxicity - concentration, duration of exposure, and individual susceptibility. The level where physiological reactions of humans or test animals begin to be observed is called the threshold level. In the case of some toxicants there may not be any threshold level i.e., any exposure - no matter how small - causes some reaction. Such pollutants without any threshold level are the most "hazardous because even the mildest exposure to these could cause trouble. Asbestos and those that emit ionizing radiation are examples of pollutants without threshold level.

Pollutants entering the body may even affect specific organs. The ability of air pollutants to penetrate the body's natural defenses differs from one pollutant to another. Carbon monoxide and hydrogen sulphide are asphyxiating pollutants, that is, they displace the oxygen being transferred to haemoglobin molecules. Hence as increasing concentrations of carbon monoxide or hydrogen sulphide are inhaled, the quantity of life-sustaining oxygen that the blood stream transports from the lungs decrease. Several hours

of exposure to carbon monoxide to 100 ppm (parts per million) results in dizziness, headache and impaired perception. With concentrations of 300-400 ppm (pans per' million) vision problems, nausea and abdominal pain may develop and 750 ppm can be fatal. Heart patients appear to be particularly susceptible to the adverse effect of carbon monoxide and hydrogen sulphide. In very high concentrations, hydrogen sulphide impairs that part of the brain that controls chest movements essential for normal breathing and causes almost instantaneous death.

Gases that act mainly as irritants of the respiratory tract, include ozone, sulphur dioxide and nitrogen dioxide.

Particles or aerosols, also penetrate the body's natural defenses and pose a serious threat to health particularly if exposed to relatively high concentration levels for many years. Silica and asbestos are causing fibrosis in the lungs. Silicosis caused from quartz dust generated during mining, asbestosis from asbestos fibers and byssinosis from cotton dust are serious lung diseases. Depending on the particulate type and the concentrations inhaled, impact on lungs may consist of irritation, allergic reactions or scarring of tissue. Typically, victims experience coughing and shortness of breath and in the long run may develop pneumonia, chronic bronchitis, and lung cancer.

Certain panicles are harmful when inhaled due to their interactions with other air pollutants. Some particles interfere with the functioning of cilica, thereby slowing the flow of mucus, and increasing the retention of toxic pollutants in lungs. It is in this way that carcinogenic agents are retained in the lungs increasing the likelihood of tumour formation. In addition particulates may act as carriers of other pollutants. For example, soot and fly ash and products of coal burning can transport sulphur dioxide into lungs.

Some toxic pollutants are so widely distributed in the general environment that to some extent they pose a potential health hazard to all human beings. Lead is the most notable of these pollutants. The danger of lead lies in the fact that it accumulates in the body more rapidly than it is excreted. Lead poisoning attacks the blood forming mechanism, the gastro intestinal tract and in several cases affects the central nervous system. Lead may also impair the functioning of heart and kidneys.

Table 5.2 Specific Health Effect of Air Pollutant

	Air Pollutant		Principally Affected Organs
1.	Sulphur oxides, nitro- gen oxides ozone, chlorine ammonia	Pulmonary irritant	Lining of respiratory tract
2.	Quarts, silica, carbon, asbestos, cobalt, iron oxides	dust	Pulmonary interestial tissue
3.	Beryllium, hair sprays, talcum powder	Granuloma producing agents	Lungs
4.	Zinc, Manganese, Hemp, cotton	Fever causing agents	Alveali
5.	Carbon monoxide, Hydrogen Sulphide	Asphyxiating pollutants	Haemoglobin Respiratory Centre
6.	Lead, mercury. Fluoride, Cadmium, Chlorinated hydro-carbons, organo - phosphates		Nerve tissue, Brains, bowels, bones, teeth, blood vessels, kidneys, fat tissue, liver
7	Formal dehyde pollen, fungi, house dust, thiocyanate, epoxy resins		Skins, respiratory tract, lungs
8	Strontium -90, Iodine -121, Chromium, Asbestos, Arsenic, Poly vinyl.	Carcinogens	bones, thyroid, lungs sinuses, nose, pleura, skin
9	Mercury, lead, arsenic, fluoride, cadmium	Mutagens	Central nervous system

Adapted from Pordom & Anderson, Environmental Science (1983)

5.8 Effect on other Species

The two air pollutants most hazardous to other species are fluoride and lead. The processing of ceramics and phosphate rock releases fluorides in to the atmosphere Some plant species are damp 1 by hydrogen fluoride at a concentration of only 0.1 parts per billion. When livestock consume these plants, the organic compounds containing fluorides break down, and the fluorides released can be lethal Dairy cattle are most sensitive to fluoride poisoning called fluorosis. Fluorides reduce milk production and attack teeth and bones producing lameness. Chromic fluorosis eventually leads to death. In Florida, substantial losses of cattle have been caused by fluoride emissions from factories promising phosphate deposits for fertilizers. Animals are also victims of lead poisoning. When contaminated by airborne lead, animals lose their appetite, develop dry coats and muscle spasms and frequently suffer paralysis.

5.9 Effect on Plants and Material Goods

Effect of air pollution on plants can be best seen near the source of pollution. For example, tree foliage along turnpikes is damaged in a band, where fumes from diesel truck exhaust, touch the leaves. Cement dust deposited on leaves, when moistered, will form incrustations, other dusts plug the leaf openings. When ozone concentration increases, pine needles turn brown and die.

Some of the most dramatic instances of air pollution damage to vegetation have been caused by sulphur dioxide fumes from iron and copper smellers. Lettuce, barley and white-pine are particularly sensitive to sulphur dioxide. "Air pollution most commonly damages the leaves of plants. Air pollution damage to plant is indicated by the yellowing of the leaves due to chlorophyll loss. This is called chlorosis which occurs when gaseous pollutants such as sulphur dioxide and ozone enter leaves and dissolve in the water that adheres to surfaces of cell walls. The pollutant can be identified by the pattern of damage to leaves. For example, fluorides accumulate at leaf tips and edges and in these areas the leaves initially turn yellow. When pollution damage is extreme, plant tissues die and leaves turn brown; this condition is called necrosis. The Table 5.3 shows significant pollutants toxic to plants.

Table5.3 Significant Pollutants toxic to plants

Pollutant	Effect on Leaves indicated by	Sensitive Plants
1. Sulphur dioxide	Turn white to brown, bleaching, blotching between veins	Pumpkins, barley, cotton, wheat, apples
2. Fluoride	Necrosis on tips and edges of leaves	Tulips, Apricots, pine, cut roses
3. Ozone	Red brown fleek	Tobacco, tomatoes, bean, potatoes
4. Oxidant Smog	Silver or bronze like on underside of leave	Lettuce, oats, pinto bean
5. Chlorine	Bleaching, necrosis on margins and between veins, scattered potting	Radish, cucumber, peaches, maple
6. Ethylene	Withering and drying of flowers, growth of retardation loss of lower buds	Tomatoes, cotton, orchids

5.9 Effects on material goods

Building, fabrics and cars are also affected by particulate matter. Acids absorbed on the particles on buildings accelerate corrosion in humid areas. Sulphur oxides speed

the deterioration of building materials especially marble and limestone. Fabrics, leather and steel are damaged when exposed to sulphur oxides. Ozone cracks rubber in auto tyres and reduces life of fibres. Nitrogen oxides can fade sensitive dyes. Chemically destructive gases and aerosols destroy invaluable works and monuments of culture and art. Some of the unique monuments like, St. Stephen's Cathedral in Vienna and Notre Dame de Paris, are endangered.

Statues and other art objects that withstood centuries of exposure in the relatively dry pollution free atmosphere of Egypt deteriorated rapidly when moved to London due to London's humid, formerly smoky sulphur oxide polluted air.

5.10 Effect on Climate

There are strong indications that pollution change; the climate. Increasing concentrations of carbon dioxide result in an increase in the absorption and radiation of infrared rays which warms the lower atmosphere. The atmosphere absorbs a large percentage of the infrared radiation that is emitted by the earth's surface. A portion of the infrared radiation absorbed by the atmosphere is then re-radiated back towards the earth's surface. Re-radiation by the atmosphere makes it difficult for heat to escape into space, so the temperature of the lower atmosphere is no more hospitable for living beings. The atmospheric gases that absorb infrared radiation are carbon dioxide, water vapour and to a much lesser extent ozone. Therefore an increase in the carbon dioxide content of the atmosphere (by air pollution activities) may result in more of the outgoing earth radiation being absorbed in the air and a warming of the earth's atmosphere. This warming effect is known as "green house effect", even though green house behaves quite differently. A green house lets in sunlight through the glass roof to warm the surfaces and air inside and physically confines the warmed air in the glass enclosure. Thus the plants are kept warm inside a "green house". The warming effect of the atmosphere by carbon dioxide hence is referred to as green house effect. In addition, growing atmospheric concentrations of halocarbons and nitrous oxides also intensify the "green house effect".

It has been found that accumulation of dust particles has the opposite effect of carbon dioxide; rather than warming the earth, an increase in dustiness, reduces the amount of solar energy that reaches the earth's surface, thus resulting in a cooling of the atmosphere. It is estimated that a rise of 3.6°C in the earth's temperature would make ice

caps in the Antarctica and the Arctic melt. The sea level will go up by about 100 metres. Most of tne major cities will be drowned and earth's coast lines will change drastically. Many believe this temperature change will come about in 108 years at the present rate of pollution.[7] On the other hand there are others who think that the cooling brought about by increasing dust particles will create another ice age. This needs a temperature drop of 4"C only. Between these two limits, some point out that the opposing forces could be made to maintain the heat balance. In sum we can say that an increase in the carbon dioxide content of the atmosphere, an increase in the amount of aerosols (dust, smoke, smog etc.) thermal pollution and other activities of this highly urbanized world, could disturb the earth's heat balance and climate.

5.11 Effect on leaves Indicated by

Air Pollution is not new. It Ls said to be at least as old as the civilisation itself. The first air pollution episode probably occurred when early people, new to the art of fire making, found that a poorly ventilated cave is no place to cook a meal. The Industrial Revolution was the greatest contributor to air pollution as a chronic problem. However, it was the tragedy at Donora, Pennsylvania, in 1948, that first brought to the world's attention the fact that air pollution, can kill. Some notable air pollution disasters are listed in Table 5.4.

Table 5.4 Some Notable Air Pollution Disasters

Years of Disaster	Location	Deaths in excess of normal mortality expectations
1880	London	1000
1930	Meuse Valley, Belgium	63
1948	Donora Valley, Pennsylvania	20
1950	Pica, Rica, Mexico	22
1952	London	4000
1953	New York City	250
1956	London	1000
1957	London	700-800
1962	London	700
1963	London	700
1963	New York City	200-400
1966	New York City	168
1962	Worldwide	1000 or more estimated
1986	Bhopal, India	More than 2000

Source: Up to 1962. Purdom Walton P. and Stanley H. Anderson: Environmental Science, Charles E. Merrill Publishing Company, London, Sydney: p. 327.

These episodes have been related to stagnant atmospheric conditions and high concentrations of particulates and sulphur oxides, and perhaps other pollutants such as metal oxides.

5.12 Air Pollution in India

In order to measure and control the magnitude of air pollution in various Industrial centres of India, National Environmental Engineering Research Institute (NEERI) has established air monitoring stations in Bombay, Calcutta, Delhi, Madras, Hyderabad, Kanpur, Jaipur, Ahmedabad and Nagpur. One of their survey reports that air pollution by SO_2 is highest in Bombay (Chembur-Trombay area) and air pollution by suspended particulate matter is highest in Delhi. The table 5.5 summarizes their result.

Table 5.5 Levels of SO_2 and suspended matter in air in 1980 in some Indian cities

City	Mean value of SO_2 micrograin/cubic meter	Suspended particulate matter microgram/cubic meter
Bombay	48.1	240.8
New Delhi	44.4	601.1
Calcutta	33.9	340.7
Kanpur	16.9	543.5
Ahmedabad	12.7	306.6
Madras	9.3	100.9
Nagpur	8.7	261.6
Hyderabad	6.1	146.2
Jaipur	5.2	146.1

Source: Katyai Timmy and Satake M: Environmental Pollution, Anmol Publications, New Delhi (1989) p, 21.

Another study by NEERI reveals a gradual but steady increase in levels of suspended particulate matter (SPM) in Calcutta since 1977 with a sixty per cent increase since 1970. The 1982-83 average concentration was reported to the 418 micrograms per cubic meter which increased to 900 micrograms per cubic meter during winter in certain places. The corresponding figure in some major cities are given in table 5.6

Table 5.6 SPM Concentration in few Major Cities for the year

City	SPM Concentration Microgram / cubic Meter
Bombay	148
Kanpur	307
Delhi	328
Madras	145
Calcutta	418

Source: Business India, May 6-19, 1985 "City of Pollution" by Psrtha S. Banerjee, pp. 89-92.

The Global Environmental Monitoring System (GEMS) also reports higher SPM concentration in Calcutta during 1976-80. Industrial emissions and automobile exhausts have been the main contributors of air pollution in India. The citizens of Bombay with over four lakh motor vehicles and Delhi with more than S.5 lakh vehicles and other major cities are already face to face with high pollution levels. In Delhi vehicles daily discharge through their fuel pipes more than 250 tonnes of carbon monoxide, forty tonnes of hydro carbon, 30 tonnes of oxides of nitrogen, more than five tonnes of sulphur dioxide and large quantities of particulate matter.[8] Vehicular traffic pollution account for fifty per cent of city's pollution and 62.5 per cent of air pollution in Bombay. Such vehicular exhausts are not only detrimental to health, they result in photo chemical smog which reduces visibility.

Such is the state of purity of air in India. The problem is likely to become worse with further urbanisation and industrial activity. Indian Government, like other nations, has framed laws and regulations to combat air pollution. But it should prescribe more rigorous standards and also implement the same more rigorously.

5.13 Bhopal Tragedy

On December 2-3, 1984, Bhopal witnessed an unprecedented tragedy caused by massive leakage of methyl-iso-cyanate (MIC) from the union carbide pesticide plant. The accident occurred because of a runaway chemical reaction in one of the tanks in which forty-two tonnes of methyl-iso-cyanate were stored. MIC was used by the plant to produce sevin, a pesticide. The runaway chemical reaction occurred because a large quantity of water entered the storage tank due to technical, insemination and managerial faults. Control instruments were faulty, refrigeration unit and other safely devices were out of commission. Vital devices like pressure guages were not functioning. To add to these, the report of a faulty valve was not attended - a decision that caused the fatal accident. As a result of all these, at least two hundred litres of water entered the storage tank setting off a rapid exothermic reaction. First and the dominant one were the reaction of MIC with itself and reaction of MIC with water. Contamination of water with MIC led to a rise in temperature and pressure in the storage tank containing large quantities of MIC. Untreated MIC along with few other gases escaped into the atmosphere as a

mixture of a highly toxic gas cloud causing unprecedented death and illness among the citizens of Bhopal. Very large number of casualties (estimates range from 2000 to 10,000 and more deaths) resulted from the release of huge quantity of the deadly gas.

5.14 Air Quality Control

Though air and water quality control programmes are analogous in effect, efforts to clean the air after pose more of a challenge than water quality programmes, since air is more mobile than water. There arc many sources of air pollution that are hazardous.

1. point sources such as from that of a smelter
2. mobile sources like autos, trucks etc.
3. line sources such as a congested highways
4. area sources, such as shopping centres.

Hence, the success of air pollution abatement is on the identification of the source of pollution. An understanding of the meteorological condition and topography in order to determine the pattern of dispersion of the emitted pollutant is also necessary. Apart from the legal measures prescribing minimum threshold levels of pollutants and minimum standards of the quality of environment, the following general measures should be taken to control air pollution.

a. The allowable emission rate should net be exceeded individual plant.
b. A continuous air pollution survey should be conducted in the concerned area and its neighboring region.
c. Air pollution control technology should be incorporated through legal requirement into design of the individual plant.
d. Meteorological conditions should be considered while deciding on the location of the industry.

The above points particularly apply to air pollution in an industrial area.

Four procedures have been outlined by the World Health Organisation in its publication (Vol 12) - Research, into Environmental Pollution. They are:

1. Containment: This refers to the prevention of escape of toxic substances into the ambient air. Containment can be achieved by a variety of engineering methods like the use of cyclones, electro-static precipitators, scrubbers etc.

2. Replacement is substitution of a technological process causing air pollution by a new process that does not pollute at least as much as the previous one. Substitution of natural gas for coal and oil would eliminate particulate emission problems from combustion, but scarcity of natural gas does render such substitution impossible.

3. Dilution: Dilution is promoted by the self-cleansing capacity of the environment. The establishment of green belts in industrial areas is an attempt at diluting the concentration and effects of air pollutants.

4. Legislation is the provision of legal policies and acts by the Government through its constitution to reduce pollution.

Essentially there are three approaches' to air pollution-control, most of which are used simultaneously.

1. The best solution is to ensure that there is good combustion. The combustion chamber must be well-supplied with oxygen and a good draft so that the temperature of the fire is as hot as possible. This will eliminate much of the dark smoke containing incompletely burnt dust and ashes.
2. The second technique is to use mechanical device. Particles from combustion and dusts from manufacturing and processing can be captured by simple air cleaning equipment. Among the most used are cyclones, scrubbers, bag houses and electro-static precipitators.
3. Chemical treatment

The Cyclone collector consists of a cylinder with a tangential inlet for gas entry and an inverted cone attached to the base. Gas enters the cyclone through tangential inlet, whirling around and around inside the cylinder. Particles in the air stream are thrown against the outer wail and settle down to the bottom from where they are withdrawn from time to time. The air that is freed of particles escapes through a duct in the centre of the cylinder. Depending on the particle size and the power used, conventional cyclones will remove about 50 to 80 per cent of particulate matter. There are wet cyclones for the removal of suspended or dissolved particulate matters from the fluid and multiple cyclones where a number of cyclones are put in a series or parallel.

Electrostatic precipitators" create a charge on particles in the air stream, through electrically charges wires that are run through a series of flues on the way to the chimney

stacks. They attract much of the ash arid dust that would otherwise fly into the open air. Electrostatic precipitators works very well on particles that become electrically charged, like carbon. Its efficiency depends on the amount of energy put into the charge, the number of precipitators in the series, and the temperature of the air stream. Sometimes electrostatic precipitators are used after cyclones. The advantages of electrostatic precipitators are:

1. Particulate collection efficiency is extremely high and collection and disposal is dry.
2. Operation is continuous with minimum maintenance.
3. Operating costs are relatively low.
4. Operation can be carried out either under high pressure orvacuum.
5. Large gas flow rates can be effectively handled.
6. Operating temperature can be as high as 100°C.

Bag houses consist of long sleeves or bags made of fabric that will withstand high temperature. As the air stream enters the sleeve and coats the fabric with particles, particles in the air stream are filtered cut as Lbs air passes through the fabric to the oilier side and escapes. Ultimately the sleeve has to be taken out of service momentarily to be blown or shaken clears. Bag houses are used along with other devices, and are more effective in removing very fine particles from air.

Scrubbers are the most effective device to control smoke. Scrubbers can be simple screens of water spray that will knock some of the large particles out of air or towers with trays of packing material to mix liquid and air. Soluble gases and particulate contaminants in the gas stream are removed by contact with a suitable liquid. The liquid collects particles by impact. In this process the scrubbing media needs to be treated before discharge failing which air pollution problem turns into water pollution problem.

One of the earliest important mechanical solutions to reduce air pollution is to build the chimney stocks higher so that the fumes will be diffused at a higher level. This, however, can cause acid-rain pollution at far away distance.

Finally, some factory fumes must be subjected to chemical treatment. Only by neutralizing them or forming some harmless byproduct can the smoke be rendered unobjectionable. It is also possible to extract undesirable elements before combustion.

Some polluting emission can be controlled only through the modification of industrial process. Industries can lower carbon monoxide concentration by supplying more air during combustion. Levels of nitrogen oxides can be reduced by decreasing combustion temperatures.

Improved air quality control programmes should not aggravate solid waste and water pollution problems by improper disposal of extracted air pollutants. An effective air quality control programme must not only require adequate control strategies, but also provide for proper disposal or refuse of collected air pollutants.

The various technological devices outlined above can successfully combat air pollution only in the presence of strict legal measures to prevent air pollution. With the problem of pollution increasing in dimensions, almost every country has its own legal measures to reduce/ prevent pollution. In the US, the Environmental Protection Agency has the primary responsibility for promoting a clean environment. The clean Air Act of 1970 and its Amendments authorised EPA to establish national ambient air quality standards for pollutants. In UK, the Modem Air Pollution Legislation dates from the Alkaline and Works Regulation Act of 1863. In Japan, the Basic Law for Environmental Pollution Control gives the national Government the responsibility to establish and implement fundamental and comprehensive policies. India is no exception to such legal measures. In India, the 42nd amendment of the Constitution has provided under articles 48A and 51A the legal foundation of environmental protection. Further the Air (Prevention and Control of Pollution) Act, 1981, prescribes emission standards for air polluting industries. We will see more of legal issues in an exclusive chapter.

Through these legal and technical measures and adequate fiscal incentives to industries reducing its emissions, air quality can be improved.

Conclusion

Air pollution is one of the very complex problems that has-come to stay with us. A point has been reached at which urgent action is needed to prevent further deterioration in air quality. We need better and newer techniques of production that would pollute less; we need to update our pollution control technology. Laws and regulations should be strictly enforced. But more important, we should tackle the basic reasons of pollution: population, increasing needs and changing consumption patterns. All these need time. Do

we have it? If not, as John K. Galbraith pointed out: The penultimate western man, stalled in the ultimate traffic jam and slowly succumbing to carbon monoxide will net be cheered to hear from the last survivor that the GNP went up by a record amount".

5.15 WATER POLLUTION

Without water all life ceases. Man is two-thirds water and the surface of the globe is seven-tenths of water. Yet the human beings pollute water in all possible ways. Water pollution is the process of altering the properties of any water which renders it unfit or less fit for the purpose its unaltered form was used - the use being natural or artificial. Dr. Key, a British expert says: "A river may be considered to be polluted when the water in it is altered in composition or condition, directly or indirectly as a result of the activities of man, so that it is less suitable for all or any of the purposes for which it would be suitable in its natural state". Water pollution may also be defined as a natural or induced change in the quality of water which renders it unusable or dangerous as regards food, human and animal health, industry, agriculture, and fishing or leisure pursuits.

Water pollution reduces the amount of pure fresh water that is available for such necessities as drinking and cleaning and for recreation activities. Water being a universal solvent readily gets contaminated by the material with which it comes into physical contact. The factors responsible for water pollution may be artificial or natural. Several natural phenomena are found to be having propensity towards polluting water. For example, draught causes water level go down in aquifirs and salt water intrusion takes place. During rain, running water gathers silt and other material. Thus natural contamination occurs in the water courses. However, more than natural factors, it is the unprecedented industrial production rate that is responsible for the scarcity of pure drinking water.

Altogether there are about 1400 million cubic kms of water on earth. Some ninety-seven per cent of it is sea water, nearly all of it permanently held in oceans. The rest is fresh water and at any time seventy-seven per cent of it is stored in the ice caps and in glaciers, a little over twenty-two per cent is ground water stored beneath the surface of the earth. Visible surface water such as rivers and lakes accounts for only 33 per cent of all the fresh water on the earth. Water has become a scarce commodity today on account of the innumerable ways in which human beings pollute water. As years go by human

beings are making increasing demands on the world's water. Industry, agriculture, irrigation, mining, power generation and the concentration of millions of people in cities watered by one or at most two rivers, all contribute to a level of pollution that threatens to outstrip human ability to clean up afterwards.

All fresh water contains dissolved materials such as phosphates, gases such as oxygen, organic compounds, suspended particulate material such as silt and micro organisms. The quantities of each vary greatly from one area to another. But a lack of balance between them or a dramatic increase in any of them, can lead to aquatic chaos in which whole ecology of the water body is upset. Then the water becomes unfit for human consumption and some or all forms of aquatic life are killed. Both effects are becoming increasingly common.

5.16 Classification of Water Pollution

Marshals I Goldman and Robert Shoop have classified water pollution as follows:

1. Pollution by Putrescible (foul smelling, rotting of organic materials by bacteria) materials
2. Pollution by heated effluents
3. Pollution by toxic materials
4. Pollution by inert materials and
5. Pollution by radio-active elements and compounds.

5.17 Pollution by Putrescible Materials

Putrescible wastes refer to foul smelling and rotting organic materials - materials like waste from humans, paper pulp plants, and canneries. Organic pollution is controlled by accelerating the process of decomposition of these organic wastes. When discharged into a stream or river or lake, the organic materials decompose by using large quantities of oxygen from water. If too much oxygen is removed and it takes too long for it to be restored, there may be serious pollution.

The amount of dissolved oxygen needed by decomposers to decompose organic materials in a given volume of water is called the biochemical oxygen demand (BOD). Thus BOD is a measure of contamination of the waste water. Human wastes are a major source of BOD. Sewage-laden waste water entering a sanitary sewer has an average BOD level of 250 ppm. This sewage-laden waste water contains only 8 ppm (parts per million)

of oxygen. Hence its oxygen is quickly depleted through microbial decomposition of sewage. In fact the decomposition of the daily wastes of a single person requires all the dissolved oxygen (DO), in 9000 litres (2200 gallons) of water. Some concentrated industrial wastes have BOD levels greater than 30 000 ppm. Other sources of high level BOD wastes include off from livestock feed lots and spoils dredged from harbours and canals.

Even in mild cases of oxygen depletion fish such as trout will not have adequate oxygen for their needs. Consequently they may die or be forced to move elsewhere. Scavenger fish like carp, which require less oxygen will only survive in such waters. Wastes from paper pulp mills discharge unusually large quantities of effluent, depleting all available dissolved oxygen.

The first zone is called the Zone of Immediate Pollution Here the dissolved oxygen content is the lowest and the odour and colour of water is affected. The second zone is Septic zone where content of dissolved oxygen is greater than in the zone of immediate pollution. Special aquatic organisms with low oxygen requirements like snails, sewage worms, and rat tail maggots may live in this zone. Because of the odour of decomposition, the area is usually easy to find. Finally there is Zone of Recovery, where the odours begin lo disappears and fish like minnows and suckers begin to appear. There is usually a large bloom of plant life or algae on the borders of Zone II and Zone III. The increased quantity of oxygen combines with decomposed organisms to break down the last traces of the organic material and create highly fertile condition.

5.18 Pollution by Heated Effluents

Oxygen is readily restored when the water is cool. The hotter it is, lower the oxygen holding capacity of the water. The bubbles that arise from heated water demonstrate what happens to the gases in hot water. The discharge of clean hot water into an unpolluted stream is hence as harmful as the discharge of organic wastes. In both cases, oxygen content of water is reduced. It is because of this that water pollution is a serious matter in tropical countries. The temperature is always so warm that it is difficult for the streams to absorb the necessary quantities of oxygen. Hot water is discharged into water courses by industries that use water for cooling. Such heated water is extremely

harmful to the fish population and many other organisms which survive only in a restricted temperature range.

5.19 Pollution by Toxic Wastes

Toxic wastes are those which do not easily settle out and are not easily broken down by biological means. Such toxic wastes like DDX and mercury are poisonous when consumed or contacted by plants and animals. Pesticides and herbicides which wash off the land into the sewers are other examples. Recently the dumping of wastes containing cyanide into the river at Ezhil Nagar, Tamil Nadu on the outskirts of Madras city is an example of this kind of pollution.

The mercury poisoning of hundreds of people in Minamata, Japan, is another example.

5.20 Pollution by Inert Wastes

Inert wastes are those which enter water as solids but are not involved in chemical reactions. Such wastes include dust, metal filings, oil films, dust and silt from soil erosion. They are removed by mechanical means such as filtering or allowing for sedimentation; these materials if not removed settle to the bottom of water course and block sunlight. As a result plant life is affected which in turn cuts off the food supply of the fish and other animal populations. For example, the oyster beds off the coast of Connecticut, Rhode Island and Massachusetts have been buried with inert wastes. Pollution from inert wastes is also a serious problem in areas located near mines.

5.21 Pollution by Radio-active Wastes

Radio-active wastes are produced in the processing of uranium and other radio-active substances or in testing of the nuclear devices that produce nuclides in blast devices and fall out. It may take years for the' level of radio-activity in the water to fall. Practically the only way known to dispose of such materials is to dump them into ocean beyond the continental shelf or pump them into abandoned mines and wells. Even this may cause pollution of oceans and underground water supplies.

5.22 Some Specific Water Pollutants

5.22.1 Pesticides

Pesticides contain chemicals that are particularly toxic to life. Pesticides enter lakes and streams through the effluent of pesticide manufacturing plants along with spray mists during application, as runoff when spraying equipment is washed and in accidental

discharges. Besides, pesticides applied in the field adhere to soil particles and are washed into stream. The most dangerous of all pesticide;: are chlorinated hydrocarbons like DDT, aldrin and dieldrin. Discharge of Kepone (a pesticide) from an industrial plant that contaminated a major section of Virginia's James River is an example of pesticidal pollution.

5.22.2 PCB

Polychlorinated biphenyls (another group of chemicals belonging to chlorinated hydro carbons) also contaminate aquatic eco-systems. PCBs are not pesticides; they are used as heat exchanging liquids, as insulating materials in electric capacitor and transformers. During the manufacture, use, and eventual disposal of these products, PCBs enter aquatic eco-systems via run off from effluent treatment plants or enter atmosphere when paper and plastics containing PCBs are burnt and become attached to dust particles. The dust particles either settle ID the ground or on surface water or are washed out of air by rain. The presence of DDT and PCBs even in insignificant levels have become such serious problems in Lake Michigan that commercial sale of Lake Michigan's highly prized Salmon fish and trout fish were banned in 1974. Consumption of food contaminated with PCBs are said to cause reproductive failure, hair loss and liver damages.

Other concentrated industrial chemicals that pose hazards both for aquatic life and human health are ammonia, cyanide, sulphide, and strong acids and alkalin.

5.22.3 Oil Spills

Oil pollution is an ever present threat to our surface waters, especially the oceanic and river water ways that are used to transport 'blackgold'. Over the past decade, several dozen major spills have occurred worldwide, and one of these incidents, the grounding and breakup of the Amoco Cadiz, on March 17, 1978, was the worst spill in maritime history. The super tanker on charter to Shell Oil, was enrooted from the Persian Gulf to English Channel Ports carrying approximately 200,000 metric tonnes of crude oil. The vessel encountered heavy seas and experienced a steering mechanism failure. Rescue attempts by tugs failed and the vessel went around 2 kms off the North West coast of France. The pounding seas broke the vessel open and the ship's entire cargo of oil soon coated 203 kms (124 miles) of the French coastline and spread to a width of 60 kms (37.5

miles). The cleanup costs totaled S 75 million and $ 35 million in damage claims were expected. Accidental oil spills however account for only four per cent of the four million metric tonnes of oil spilled into oceans each year. The major causes of oil spills are collisions and groundings of tankers and bargers, oil well blow out and ruptures or leakages of oil storage tanks and pipe lines. Such oil spills kill important plants and animals in the oceans.

5.23 Effects of Water Pollution

In many of the developed countries of the world almost complete eradication of the water-borne diseases has been achieved. But not so with developing countries. Water is a significant vehicle in the transmission of disease when it contains water borne pathogens or disease producing organisms. These pathogens, which can be viruses, bacteria, protozoa (single celled animals) parasitic worms cause such diseases as dysentery, typhoid fever, cholera, and infections hepatitis. Table 5.7 shows some of the more common water borne diseases and their characteristics.

Table 5.7 Water borne diseases transmitted through drinking water and food

Disease	Type of Organism	Symptoms and Comments
Cholera	Bacteria	severe vomitting, diarrhoea and dehydration; often fatal if untreated
Typhoid	Bacteria	severe vomitting, diarrhoea, inflamed intestine, enlarged spleen – often fatal if untreated
Bacterial Dysentery	Several species of bacteria	Diarrhoea
Para-typhoid fever	Several species of bacteria	severe vomitting, diarrhoea
Infectious hepatitis	Virus	Yellow jaundiced skin, enlarged liver, vomitting and abdominal pain - often permanent liver damage
Ameobic dysentery	Protozoa	Diarrhoea possibly prolonged

Source: Moran J.M., M.D. Morgon and J.H. Wiersma, Introduction to Environmental Science, W.H. Freeman & Company, San Francisco.

There are other diseases particularly prevalent in developing areas, transmitted through polluted water, urban filariasis for example, is transmitted through mosquitos breeding in polluted water.

Analysing water for the presence of specific pathogens is time-consuming, costly and difficult.[3] Therefore microbiologists usually analyse for a more readily identifiable group of bacteria called coliforms. Since these organisms are normally present in the intestinal tract of humans and animals, large number of coliforms in a water sample indicate contamination by untreated sewage. When coliform organisms are found in drinking water, municipalities either chlorinate drinking water more heavily or seek alternative uses. But chlorination itself may give rise to other pollution problems.

5.24 Effect on Industrial Water Supplies

Water pollution may reduce the utility of water for industrial purposes. The range of quality required or desirable in industrial application is very wide. Cooling water can often be of comparatively low sanitary quality but the presence of waste heat and of corrosive materials is undesirable. Some processes require unusually soft water; others can tolerate hard water. So polluted water can involve substantially high costs for industries - the costs of purifying the water, of repairing damaged equipment or of making extensive adjustments to industrial process themselves.

5.25 Water Pollution and Agriculture

Water pollution can greatly affect the productivity of irrigated land. Irrigation itself is a major cause of water pollution. All natural water contain inorganic salts, particularly chloride. As irrigation water evaporates in the field, the salt concentrates in the wet soil. If they are allowed to accumulate, fertility would diminish and eventually land would become barren. They must therefore be washed away. If this is done by subsequent heavy rainfall little harm will result because salt will be diluted. But if salts are removed by using excessive irrigation water salt get concentrated in drainage, which often goes back to the river. The drainage (trill also carry away salts applied to land as fertilisers, the consequence of all these will be an increase in the salinity of river water. Irrigation may itself therefore produce pollution problem.

5.26 Aquatic Food Resources

The effects of the water pollution on fisheries are well-known. Fish may be killed directly by specific toxins or through oxygen depletion. The changes in temperature affect their breeding and their fitness as food may be spoiled or their market value lowered through changes in favour or through contamination by pathogenic organisms.

Commonly used pesticides like DDT may also kill fish., For example, an adverse effect of water pollutants on aquatic life in the Minamata tragedy. In the 1960s, forty-one people died and seventy more were seriously ill after eating fish caught in Japan's Minamata Bay. The sickness, which later came to be known as Minamata disease, was caused by concentrated mercury in the fish - upto 1.5 mg. per kg. Mercury occurs naturally in sea water but in almost insignificant quantities. Where rivers carrying waste waters from the plastics, paint, chemical and paper industries flow into coastal waters, however, levels of mercury, may be far above the normal. Fish then concentrate the mercury. Tuna and sword fish have been found with a hundred times as much mercury in their bodies as the surrounding water contains. In 1980, Mediterranean Tuna contained around 1.26 me. per kg. of mercury - more than four times as much as is found in fish caught in Pacific Ocean.

Now-a-days, the levels of metal pollution in mussels in coastal waters off the United States are measured regularly. Since the mussels concentrate such pollutants in their tissue, they make a useful barometer of the health of the coastal waters. The presence of lead, cadmium, zinc, copper, nickel, plutonium, caesium, halogenated hydro carbons, and petroleum hydro carbons can be regularly checked in this way. This is one reason why eating shell fish from polluted waters is potentially so dangerous.

The most obvious effects of pollutants can be observed in the semi enclosed seas such as the Gulf of .Mexico, the Mediterranean and the Baltic sea. In -some places, contamination is so severe that sale of fish had to be banned. Decline in the number of certain species of aquatic mammals is also due to water pollution.

Aesthetic and Recreational Considerations also should be considered in an analysis of effect of water pollution. Polluted water with low DO (or high BOD) make water unfit for swimming and many water sports popular in most of the developed countries. Aesthetically it is not only the odour that is offensive but also the floating materials. Floating sewage solids especially, suspended sediments and industrial wastes reduce visual appeal of water. Dense algae growth make water both unattractive and stinking.

5.27 Control of Water Pollution

Control of water pollution essentially involves treating of effluents discharged by industries and treating of sewage by providing for more sewage treatment plants.

Sewage treatment proceeds in three stages. In the primary treatment stage solid wastes are removed through mechanical process and the organic matter is removed by biological process in the secondary treatment stage. Virtually all the remaining pollutants are removed in the tertiary stage. Phosphates are the most difficult to be removed even after the tertiary treatment is over. Hence in some cases the phosphates and nitrates are channelled into land as fertilisers. For complete removal of pollutants more advanced waste treatment methods are used. Some of them are:

1. Chemical coagulation method
2. Chemical oxidation method
3. Carbon absorption method
4. Ion exchange method
5. Electro dialysis and
6. Reverse osmosis.

The costs of advanced treatments are higher than primary and secondary treatments.

Recycling of wastes, removal of specific pollutants through ion exchange technique, by use of polymeric absorbents is also in practice. The technological measures along with legal enforcements to Deal wastes can be successful in combating water pollution, only if ultimately all human beings realise their moral responsibility towards protecting water. During the region of King George III, a British Member of Parliament appears to have written a letter complaining of the water quality of River Thames. The letter, it is said, was written, in water taken from the river. Things have improved with Thames today. It should similarly improve in other water systems also. it will improve with strict regulations and stricter implementation of the regulations.

5.28 Majority Polluted waters of this century

5.28.1 Lake Erie (USA) Case 1

The story of the Lake Erie on the US / Canadian border illustrates just how complex the chain of contamination in fresh water ecology can be. By the mid 1960s pollution there had become so severe that nearly all the popular beaches had been

abandoned and enormous piles of decaying fish and algae piled up on the shores of the lake every summer. One particularly attractive inhabitant, the mayfly had disappeared altogether. The fish catch in 1956 of 6.9 mln. pounds of blue-pike fell to 200 pounds in 1963.

Every summer, as the lake warmed, huge algae blooms, appeared on the lake. These blooms are caused by the presence of all the artificial fertiliser in the form of phosphates and nitrates released into the lake from the surrounding sewage plants. But the algae died as quickly as they grew. Once dead, they sank to the bottom, forming a thick layer of organic matter, which depleted the oxygen level of the lower levels of the lake. This resulted in the death of fish and many other aquatic organisms. This process is called eutrophication. Normally it should take hundreds of thousands of years. But the process has accelerated on Lake Erie with an almost unbelievable speed. It is estimated that it will cost billions of dollars to clean up.

5.28.2 Rhine, River Basle Case 2

On November 1, 1986, a fire destroyed a warehouse operated by Sandoz, the multinational pharmaceutical company, in Schwei Zerhalle, about 6 miles south east of Basle. About thirty tonnes of agricultural chemicals and solvents and 440 pounds of mercury were spilled into Rhine. Rhine became almost dead. The whole eco-system was destroyed as a result of the accident. After the accident, toxic level in Rhine increased six times above normal. Using Rhine water for drinking purposes or for fishing was prohibited. The Swiss Government and the Sandoz Company were blamed for the negligence, by the Fr: and Germans. The French Government presented to Swiss Government a bill for S 38 million for the environmental damage France inflicted through this disaster.

5.28.3 Pollution of River Ganga Case 3

River Ganga, the cradle of Indian civilisation, is the most ex ten riverine system of India. Emerging from the mountainous glacier o: Himalayas, it covers a long stretch of about 804 km., covering the m. part of northern India. But it is today one of the most polluted river its journey from the Himalayas to the Bay of Bengal, it receives r bulk of urban, agricultural and industrial effluents which make the water polluted and un-potable. About 132 medium and large industrial discharges their untreated effluents into the river

adding to the sewage and sludge disposal of the 100 townships located on the banks. To fed these until 1989, a large number of the dead bodies or the ashes (A dead were also immersed in Ganga as it is considered by Indians as the Holy River. Pollution in river Ganga may be classified as biological an; chemical pollution. Biological pollution is due to discharge of untreated urban municipal sewage and sludge's, immersion of dead bodies etc. As a result of this water borne diseases are reported to be high in the Ganga basin. It is reported that three persons die every minute in Ganga basin due to diarrhea. Chemical pollution is caused by discharge of untreated effluents by the industries and surface runoff from agricultural fields. As a result of this, there is an increase in turbidity, ionic concentration and decrease in dissolved oxygen (DO) content This adversely affects the aquatic life.

Ganga water is known for its high self purifying capacity. It has been scientifically proved that Ganga water has the ability to kill seventy-five percent of the harmful bacteria within 24 hours. But today due to extensive pollution, the regenerative self-cleansing power of the river is gradually declining.

The 560 million Ganga Action Plan that started on a war-footing last June aims at setting up sewage treatment plants to tackle 1000 , million litres of sewage per day from 27 cities on the bank of river before it is discharged into the river. The principal thrust of the Ganga Action Plan in the first phase is immediate reduction of the pollution load on the river and establishment of treatment plants which are technically and financially self-sustaining. Renovation of existing sewers, construction of interceptors, renovation / construction of new treatment plants, feeding human/animal wastes for sewage / sludge digestion, provision of sewage / sludge pumping station, establishing biological conservation schemes, pilot projects etc., are some of the measures proposed under the CAP.

5.29 Water Pollution in India

Rivers and lakes are the carriers of wastes generated by production and consumption activities of the human beings. Drinking water for most Indian cities comes from rivers and other surface sources. Ail the fourteen major rivers of India are subject to severe contamination and pollution today. The fourteen major rivers carry eighty-five per cent of the surface run off and their drainage basin covers seventy-three per cent of the

country. The chief contaminants of our rivers and lakes are city sewage and industrial wastes. About seventy per cent of the water bodies in India are polluted. Sixty-four highly polluting industries discharge more than one million litre per day of toxic, industrial effluents. Mostof the cities lack sewage treatment plants. A mere five to seven per cent of the population is covered by sewerage facilities and only three per cent have access to sewerage treatment plants. According to an estimate seventy per cent of Indian waters are of "doubtful quality" for conventional treatment with BOD exceeding five parts pe» million (ppm). Large scale destruction of aquatic life have been reported due to lack of dissolved oxygen content which is due to the effluents discharged by the industries into rivers like Damodar, Sone, Cauvery, Krishna, Mahi and Kalu. Industrial wastes and sewage combine to pollute river Ganga.

In the Sone River, fish casualties have been high from chemical wastes discharged by factories near, Mirzapur in Ultar Pradesh. The chlorine content of the wastes is estimated upto sixty-two parts per million (1970) when tolerable limit is mere 1 ppm. Paper mills also add to the pollution of this river.

Pollution of the Jamuna between Delhi and Agra is due to DDT plants near Delhi and hence is highly toxic. Sewage from Delhi is also cleared into Jamuna. The Andhra Paper Mills dump about 4500 gallons of toxic waste in Godavari River every day. The Hoogly estuary is choked with industrial wastes from more than 150 major factories which include 87 jute mills, 12 textile mills, 7 tanneries and 5 paper and pulp factories. Every day on its 4fl km stretches through Delhi, Yamuna picks up nearly 226 million litres of untreated sewage and industrial wastes. Yamuna receives everyday about 6000 kg. of dissolved solids, 3000 kg of heavy metals and 200 kg. of detergents. Gomti River in Lucknow is polluted by paper and pulp mills and sewage. Table 9.2, summarizes the major sources of pollution of Indian rivers.

Table 9.2 Some Indian Rivers and their Major Sources of Pollution

S. No	Name of the River	Sources of Pollution
1	Kali (UP) at Meerut	Sugar mills, paint, detergents, rayon and silk industries
2	Jamuna near Delhi	DDT factory,
3	Ganga at Kanpur	Sewage Jute, Chemical, metal and surgical industries, tanneries, sewerage.
4	Gomti near lucknmow (UP)	Paper and pulp mills, sewage
5	Damodar between Bokaro and Panchet	Fertiliser, fly-ash and steel mills and thermal power stations
6	Hoogly near Calcutta	Power station, jute, chemical, steel, paper, textile mills and sewage.
7	Sone at Dalmianagar (Bihar)	Cement, paper and pulp
8	Bhadra (Karnataka)	Pulp, paper and steel industries
9	Cauvery	Tanneries, Distilleries, sewage
10	Kalu (between Bombay and Kalyan)	Chemical factories, rayon mills and tanneries

Sources Environmental Pollution, Timmy Katyal and M. Satake, p. 75.

Our lakes are also polluted. The Dal Lake for example, has shrunk to 11 sq. km. from 22.5 sq. km. in 1947. Floating garden occupy about 3.9 sq. km. and threaten a further 1.4 sq. km. Wastes from house boats, hotels and residential house pollute the lake.

It is estimated that on account of pollution of our rivers and lakes, more than sixty per cent of the diseases are water-borne and nearly seventy-three per million working days are lost due to these diseases. Also they account for a loss of productivity of the value of about sixty crores a year.

Realizing the growing menace of the problem the Government of I enacted the water (Prevention and Control of Pollution; Act, 1974, and formed the Centra Boa for Prevention and Control of r Pollution. It is necessary that strict actions are taken against the polluter. The Government agencies should follow whether tries adhere strictly to the norms prescribed. Besides me lid be provided with adequate sewerage facilities and treatment plants. Only these measures can save our waters from being polluted further.

5.30 Soil Pollution

Soil pollution occurs when the presence of toxic chemicals, pollutants or contaminants in the soil is in high enough concentrations to be of risk to plants, wildlife, humans and of course, the soil itself. Arable land is turning to desert and becoming non-

arable at ever-increasing rates, due largely in part to global warming and agricultural fertilizers and pesticides, lessening the hope that we can feed our booming population. Within 40 years, there will be over 2 billion more people, which is the equivalent of adding another China and India. Food production will have to increase at least 40% and most of that will have to be grown on the fertile soils that cover just 11% of the global land surface. However, there is little new land that can be brought into production and existing land is being lost and degraded. The United Nations Food and Agricultural Organization states that annually, 75 billion tons of soil, the equivalent of nearly 10 million hectares, which is about 25 million acres, of arable land is lost to erosion, water-logging and salination and another 20 million hectares is abandoned because its soil quality has been degraded. Contact with contaminated soil may be direct, from using parks, schools etc., or indirect by inhaling soil contaminants which have vaporized or through the consumption of plants or animals that have accumulated large amounts of soil pollutants, and may also result from secondary contamination of water supplies and from deposition of air contaminants.

5.31 Causes of Soil Pollution

The redundant, ever-increasing use of chemicals such as pesticides, herbicides, insecticides and fertilizers is one of the main factors causing soil pollution by increasing its salinity making it imperfect for crop bearing and adversely affecting the microorganisms present in the soil, causing the soil to lose its fertility and resulting in the loss of minerals present in the soil, thus causing soil pollution and killing off more than just the intended pest. Other types of soil contamination typically arise from radioactive fallout, the rupture of underground storage tanks, percolation of contaminated surface water to subsurface strata, leaching of wastes from landfills or direct discharge of industrial wastes to the soil, unfavorable and harmful irrigation practices, improper septic system and management and maintenance, leakages from sanitary sewage, acid rain falling onto the soil, fuel leakages from automobiles, that get washed away due to rain and seep into the nearby soil and unhealthy waste management techniques, which are characterized by release of sewage into the large dumping grounds and nearby streams or rivers.

5.32 Effects of Soil Pollution

Soil pollution can have a number of harmful effects on ecosystems and human, plants and animal health. The harmful effects of soil pollution may come from direct contact with polluted soil or from contact with other resources, such as water or food which has been grown on or come in direct contact with the polluted soil.

5.33 Effects of Soil Pollution on Environment

According to Pollution Issues, soil pollution naturally contributes to air pollution by releasing volatile compounds into the atmosphere - so the more toxic compounds soil contains, the greater the air pollution it creates - and can lead to water pollution if toxic chemicals leach into groundwater or if contaminated runoff or sewage, which can contain dangerous heavy metals, reaches streams, lakes, or oceans. When applied repeatedly or in large amounts, these heavy metals can accumulate in soils to the point that it is unable to support plant life. Moreover, soil pollution allows great quantities of nitrogen to escape through ammonia volatilization and denitrification and the decomposition of organic materials in soil can release sulfur dioxide and other sulfur compounds, causing acid rain.

Furthermore, acidic soils created by the deposition of acidic compounds, such as sulfur dioxide brought about by the burning of fossil fuels, produce an acidic environment that harms micro-organisms, which improve the soil structure by breaking down organic material and aiding in water flow. Soil pollution may alter plant metabolism and reduce crop yields and cause trees and plants that may absorb soil contaminants to pass them up the food chain. Soils polluted by acid rain have an impact on plants by disrupting the soil chemistry and reducing the plant's ability to take up nutrients and undergo photosynthesis. Soil pollution also causes the loss of soil and natural nutrients present in it, hindering plants ability to thrive in such soil, which would further result in soil erosion and disturbing the balance of flora and fauna residing in the soil.

While aluminum occurs naturally in the environment, soil pollution can mobilize inorganic forms, which are highly toxic to plants and can potentially leach into ground water, compounding their effects. Soil pollution increase the salinity of the soil making it unfit for vegetation, thus making it useless and barren. If some crops manage to grow under these conditions, they would be poisonous enough to cause serious health problems

in people consuming them. The creation of toxic dust is another potential effect of soil pollution. Furthermore, contaminated soils with high levels of nitrogen and phosphorus can leach into waterways, causing algal blooms, resulting in the death of aquatic plants due to depleted dissolved oxygen. Finally, acidic deposition into the soil can hamper its ability to buffer changes in the soil pH, causing plants to die off due to inhospitable conditions.

5.34 MARINE POLLUTION

Marine pollution refers to the contamination or presence of pollutants in oceans and seas. The word 'marine' comes from the Latin word for 'sea' and it is related to similar words, such as 'mariner'. Ocean pollution is become ever more of a problem in the present day.

Marine pollution can be defined as anything that contaminates the sea. Common marine pollutants include chemicals, small plastic beads in exfoliants and also toxic bio-matter (such as sewage). But, noise – due to excessive traffic around the ocean – can also be defined as pollution if it disrupts marine life.

Pollution can vary depending on the context and the purpose for which seawater is being used. For example, normal seawater has some small particles of plants or sand in, and when the sea is considered as the habitat of marine animals, one would not think of these particles as pollutants – whereas one would definitely define toxic chemicals as pollutants. However if somebody wanted to use this brine for cooking in, they might see the sand and plants as polluting our cooking water.

5.35 Causes/Sources of Marine Pollution

5.35.1 Toxic chemicals in water

Chemical runoff from industry can really endanger marine life. Industrial waste pumped into the sea, household cleaners poured down the sink, and even chemicals in the atmosphere (for instance due to the discharge of industrial wastes through factory chimneys) that dissolve into the sea can pollute our oceans significantly.

5.35.2 Oil spillages

This is usually an accidental form of industrial dumping, whereby leaks in oil tankers cause vast quantities of oil to pour into the ocean. Accidental oil spills can devastate marine life.

5.35.3 Small particles

The tiny plastic beads in exfoliating creams and other small particles that we pour down the drain without thinking wind up polluting the ocean.

5.35.4 Plastic, Litter, and human waste

Plastic bags, aluminum cans, trash and other human waste constitute a major pollutant of the world's oceans. A huge 'island' of trash roughly the size of Texas was recently found in the Pacific ocean for instance, demonstrating the vast scale of this problem.

5.35.5 Sewage

Whether or not it is treated with toxic chemicals, sewage pollutes the clear, clean water of the oceans. This is another type of industrial dumping. Sometimes, sewage is not pumped directly into the sea but into rivers, and then the untreated water of rivers carries it into the sea.

5.35.6 The shipping industry

Gases (which dissolve in the sea), chemicals and sewage from container ships are major pollutants.

5.35.7 Dissolved greenhouse gases

Greenhouse gases from human fossil fuel consumption are making the sea more acidic.

5.36 Effects of Marine Pollution

5.36.1 Oxygen depletion

Seawater is full of dissolved oxygen, however decomposing sewage and other biomatter in oceans can result in a condition known as 'hypoxia' or oxygen depletion. This makes it hard for oxygen loving marine life – plants, fish and animals – to survive in the oceans.

5.36.2 Higher acidity

Toxic chemicals make our oceans more acidic. Again, this makes them poisonous to marine life and causes harm to fish and marine mammals as well as marine plants and corals.

5.36.3 Choking marine life

Small pieces of plastic and other litter are increasingly being found in the stomach of fish, turtles and other marine animals. These pieces of trash choke marine animals and hamper their digestion, with an often fatal result.

5.36.4 Spoiling birds' feathers

Oil spills coat the feathers of marine birds and strip them of the natural oils that birds use to keep their feathers waterproof and to maintain their own body temperatures. As a result, marine birds can overheat or get too cold, and they find it hard to stay afloat as their feathers get soggy. They will also find it difficult to fly when their feathers are clogged with oil.

5.36.5 Blocking out the sunlight

Pollutants such as oil or litter can block out the sunlight from sea plants which need sunlight for photosynthesis.

5.36.6 Dangers to human health

Human swimmers and water sports lovers can become endangered by swimming in a polluted sea.

5.37 Control Measures/ Solutions for Marine Pollution

5.37.1 Becareful with our chemicals

Climate change and marine pollution are both results of excess human interference in the natural world. If we choose eco-friendly household cleaners and take measures to reduce the fumes we release into the air (for instance, by choosing public transport over cars) we can reduce the impact of our lives on the oceans.

Further, careful site monitoring to prevent or stop any chemical or oil spills at all times will reduce the instances of oil spills.

5.37.2 Don't flush or rinse away harmful particles

If we do not flush plastics down the toilet, and if we do not pour oils and exfoliating beads down the faucet, we prevent these particles from reaching our oceans. Switch to exfoliants that use natural materials like seeds, sugar or sand instead – and recycle all plastics.

5.37.3 Campaign

Influence the decisions of policymakers and factory bosses to make them more eco-friendly by lobbying, writing letters, spreading the word on social media and campaigning. Motivating the shipping companies to use safe and environmentally friendly vessels are among the key measures that can be taken here.

5.37.4 Volunteer at an oil spill site

Volunteers are always needed at oil spill sites to save the lives of marine birds by washing the oil from their feathers and caring for them until they are ready to fly, swim and dive under water again. Intervention is always needed as soon as possible to ensure that these birds do not suffer any ill effects to their health.

5.37.5 Volunteer at a beach cleanup – or organize one yourself

Rid your local beach of litter by getting together with the rest of the community to pick up the trash left behind by careless picnickers, boat crews and more. Joining together as a community to care for the natural world is a wonderful way to remind everyone how intimately we are connected to nature, and how much we depend on it. Working together with other people also helps to keep us motivated and reminds us that we are not alone in our quest to care for the environment.

5.37.6 Ensuring no debris is released into the ocean

Recycling our plastics and other recyclable, and disposing of our waste responsibly is key here.

Marine pollution is a serious issue, and it comes in many forms. Nevertheless, there are several ways that we can take positive action right now to solve this problem of marine pollution. We should never think that our individual actions do not count when it comes to caring for the environment: they do! If we refrained from dumping rubbish in the ocean, for instance, every single individual on this earth could prevent several tonnes of trash from spoiling the habitats of marine animals – this is no small achievement! And, when we club together with other people, our ability to fight marine pollution becomes even bigger. So why not start today? Write to your local authority, organize a beach cleanup, research environmentally friendly household cleaning products and stop using exfoliating products containing plastic beads. You could save a life in the sea today.

5.38 INDIA'S ENVIRONMENTAL POLICY

A developing country like India has several challenges in economic, social, political, cultural and environmental arenas. All of these unite in the dominant imperative of alleviation of mass poverty, reckoned in the multiple dimensions of livelihood security, health care, education, empowerment of the disadvantaged, and elimination of gender disparities. The present national policies for environmental management are contained in the National Forest Policy 1988, the National Conservation Strategy and Policy Statement on Environment and Development 1992; and the Policy Statement on Abatement of Pollution 1992. Some sector policies such as the National Agricultural Policy 2000; National Population Policy 2000; and National Water Policy 2002; have also contributed towards environmental management. All of these policies have recognized the need for sustainable development in their specific contexts and formulated necessary strategies to give effect to such recognition. The National Environmental Policy seeks to extend the coverage, and fill in gaps that still exist, in light of present knowledge and accumulated experience. It does not displace, but builds on the earlier policies.

5.39 Key Environmental Challenges: Causes and Impacts

The key environmental challenges that the country faces relate to the nexus of environmental degradation with poverty in its many dimensions, and economic growth. These challenges are intrinsically connected with the state of environmental resources, such as land, water, air, and their flora and fauna. The proximate drivers of environmental degradation are population growth, inappropriate technology and consumption choices, and poverty, leading to changes in relations between people and ecosystems, and development activities such as intensive agriculture, polluting industry, and unplanned urbanisation. However, these factors give rise to environmental degradation only through deeper causal linkages, in particular, institutional failures, resulting in lack of clarity or enforcement of rights of access and use of environmental resources, policies which provide disincentives for environmental conservation (and which may have origins in the fiscal regime), market failures (which may be linked to shortcomings in the regulatory regimes), and governance constraints. Environmental degradation is a major causal factor in enhancing and perpetuating poverty, particularly among the rural poor, when such

degradation impacts soil fertility, quantity and quality of water, air quality, forests, wildlife and fisheries. The dependence of the rural poor, in particular, tribal societies, on their natural resources, especially biodiversity, is self-evident. Women in particular face greater adverse impacts of degradation of natural resources, being directly responsible for their collection and use, but rarely for their management. The commitment of time and effort in collection of these resources has a direct impact on the capacity of rural women to devote time to raising and educating children, enhancing their earning skills, or participating in gainful livelihoods.

5.40 Objectives of the National Environment Policy

5.40.1 Conservation of Critical Environmental Resources:

To protect and conserve critical ecological systems and resources, and invaluable natural and man-made heritage, which are essential for lifesupport, livelihoods, economic growth, and a broad conception of human well-being.

5.40.2 Intra-generational Equity: Livelihood Security for the Poor:

To ensure equitable access to environmental resources and quality for all sections of society, and in particular, to ensure that poor communities, which are most dependent on environmental resources for their livelihoods, are assured secure access to these resources.

5.40.3 Inter-generational Equity:

To ensure judicious use of environmental resources to meet the needs and aspirations of the present and future generations

5.40.4 Integration of Environmental Concerns in Economic and Social Development:

To integrate environmental concerns into policies, plans, programmes, and projects for economic and social development

5.40.5 Efficiency in Environmental Resource Use

To ensure efficient use of environmental resources in the sense of reduction in their use per unit of economic output, to minimize adverse environmental impacts.

5.40.6 Environmental Governance

To apply the principles of good governance (transparency, rationality, accountability, reduction in time and costs, participation, and regulatory independence) to the management and regulation of use of environmental resources

5.40.7 Enhancement of Resources for Environmental Conservation:

To ensure higher resource flows, comprising finance, technology, management skills, traditional knowledge, and social capital, for environmental conservation through mutually beneficial multi-stakeholder partnerships between local communities, public agencies, the academic and research community, investors, and multilateral and bilateral development partners.

5.41 ENVIRONMENTAL PROTECTION POLICIES IN INDIA

The environment is a complicated dynamic system, with many interacting components. Our knowledge of these components, of their interactions between them, and the relationship between people, resources, environment and development has undergone profound evolution over the last many years. Environment problems arise in virtually all sectors of human activity in both the developing and developed countries. In modem time society's interaction with nature is so extensive that it has given rise to what we know as the environmental question affecting all humanity. Environmental deterioration can be attributed to industrialization and urbanization, the depletion of traditional sources of energy and raw materials, constant population growth, the disruption of natural ecological balances, the destruction for economic ends of various animal and plant species, and the negative genetic consequences of the industrial and other pollutants, which include the danger of man's genetic degeneration. Steady scientific and technical progres3 has secured an unprecedented growth of man's power in relation to nature. We have built on a scientific and technical civilization that is encroaching heavily on nature. Our industrial, economic, scientific and technical activity has not simply attained a geological scale, but also a cosmic one as well. We are now creating new seas, and transforming huge deserts into fertile oases. In general we are in a position to encroach upon nature without limit, remaking her more and more radically. But we cannot and must not exercise all our power over nature without restrictions, without allowing for the possible negative consequences of our activity

The main environmental problems in India relate to air and water pollution; degradation of common property resources; threat to bio-diversity; solid waste disposal and sanitation. Increasing deforestation, industrialization, urbanization, transportation and input-intensive agriculture are some of the major causes of environmental problems faced

by the country. Poverty presents special problems for a heavily populated country with limited resources. Noxious and toxic substances like Sulphur dioxide contaminate water, oxides of nitrogen, and suspended particulate matter are senous air pollutants in industrial regions and cities. Other problem is noise pollution, which occurs mainly in commercial and residential areas as a result of vehicular traffic, industrial activities, and religious festivals. These three major problem water, air and noise pollution are constantly discussed in various forums. Mindful of the seriousness of environmental pollution problems in India, the judiciary has on several occasions ruled that polluting activity by individuals, industries and corporate bodies should cease.

5.42 THE GOVERNMENT OF INDIA'S RESPONSE TO ENVIRONMENTAL CONCERNS

The year 1972 marked a watershed in the history of environmental management in India. Prior to 1972 different Union ministries dealt with environmental concerns such as sewage disposal, sanitation and public health, and each pursued these objectives in the absence of a proper coordination system at the central or intergovernmental level. When the 24th United Nations General Assembly decided to convene a conference on the human environment in 1972, and requested a report from each member country on the state of their environment, a committee on the Human Environment under the chairmanship of Pitambar Pant, a member of the Planning Commission, was set up to prepare India's report. By May 1971 three reports had been prepared, so with the help of these reports, the impact of the population explosion on the natural environment and the existing state of environmental problems were examined. By early 1972 it had been realized that unless a national body was established to bring about greater coherence and coordination in environmental policies and programs to integrate environmental concerns in the plans for economic development, an important lacunae would remain in India's planning process. Consequently, on 12 April 1972 a National Committee on Environment Planning and Co-ordination (NCEPC) was set up, as a high powered advisory body to the Govern~ent. Within its purview falls the appraisal of development projects, human settlements planning, survey of natural eco-systems like wetlands, and spreads of environment awareness. On the recommendation of the NCEPC Environment Boards in every state and union territory had been set up. Until the General election of 1977, none of the political parties in India considered environmental problems worthy of inclusion in

their election platforms. But thereafter a number of environmental controversies such as Silent Valley and Mathura Refinery causing acid rain on the Taj Mahal sparked public concern, and as a consequence major political parties (Congress-I, Lok Dal, Janata and Congress-U) included environmental matters in their 1980 general election manifestoes. Congress won the election and it immediately set up a committee headed by N.D. Tiwari. On the recommendation of Tiwari Committee a separate Union Department of Environment was set up in November 1980 to act as a nodal agency for environmental protection and eco-development work and to carry out environmental appraisal of development projects. Responsibility for pollution monitoring and regulation and conservation of marine eco-systems and critical eco-systems designated as biosphere reserved is also assigned to it. The Department of Environment was put under the direct supervision of the Prime Minister with a Deputy Minister in Charge of the Department.

Following another recommendation of the Tiwari committee the NCEPC had been replaced by a National Committee on Environmental Planning (NCEP), with functions similar to those of its predecessor. The NCEP was formed in April 1981 and authorized to prepare an annual 'state of the environment' report, to arrange public hearings or conferences on significant environmental issues, establish a nationwide environmental information and communication system and propagate environmental awareness through the mass media. Because these duties, as well as its management functions, overlapped in some respect with those of the Department of Environment, it appeared that one agency was being relegated to a subservient role. The hope did not materialize that NCEP could acquire the status and act in a manner similar to that of the United States Council on Environmental Quality to rectify the apparent problems of overlapping jurisdiction and authority pattern.

5.43 Environment and the Constitution

The Constitution of India is one of the few in the world having specific provisions for the protection of environment. These provisions came to be incorporated in the constitution in the post-Stockholm period. A Constitution amendment for the first time inserted relevant provisions in Part IV (Directive Principles of State Policy) and Part IV A (Fundamental Duties) of the constitution. In Part IV relating to Directive Principles of State Policy, the Article 48 A was added which is as follows: "48A Protection and

improvement of environment and safeguarding of Forests and Wild-life. The State shall endeavor to protect and improve the environment and to safeguard the forests and wildlife of the country.

A new clause in the Fundamental Duties of Article 51A (g) was added in the Constitution of India, Article 51 A (g) the part is as follows: "51 A. Fundamental Duties- It shall be the duty of every citizen of India- (g) to protect and improve the natural environment including forests, lakes, rivers and wild life, and to have compassion for living creatures". Besides these Constitutional Provisions which provide for environmental protection, in the three lists of the Seventh Schedule of the Constitution of India, the following entries exist which permit the Union or the State or both, to make laws having a bearing, directly or indirectly, on environment.

5.43.1 List I -Union List

6. Atomic Energy and mineral resources necessary for its production.

14. Entering into treaties and agreements with foreign countries and implementing of treaties, agreements and convention with foreign countries

24. Shipping and navigation, including shipping and navigation on tidal waves

25 Maritime shipping and navigation, including shipping and navigation on tidal waves

29. Airways, regulation and organization of air traffic and of aerodromes

52. Industries, the control of which by the Union is declared by Parliament by law to be expedient in the public interest

53. Regulation and development of oil fields and mineral resources.

54. Regulation of mines and mineral development to the extent to which such regulation and development under the control of the Union is declared by Parliament by law to be expedient in the public interest

56. Regulation and development of inter-state rivers and river valley

57. Fishing and fisheries beyond territorial waters

5.43.2 List II State List

6.Public health and sanitation; hospitals and dispensaries

10. Burials and Burial grounds; cremations and cremation grounds

14. Agriculture, including agricultural education and research, protection against pests and prevention of Plant disease

15. Preservation, protection and improvement of stock and prevention of animal diseases

17. Water, that is to say, water supplies, irrigation and canals, drainage and embankment, water storage and water power subject to the provisions of entry 56 of List I

18. Land, that is to say, rights in or over land, land tenures including the relation of landlord and tenant and the collection of rents; transfer and alienation of agricultural land, land improvement and agricultural lands; colonization.

21. Fisheries.

5.43.3 List III - Concurrent List:

17. Prevention of cruelty to animals

17A. Forests

17B. Protection of wild animals and birds

18. Adulteration of foodstuffs and other goods

19. Drugs and poisons subject to the provisions of Entry 59 of List I with respect to opium

20. Economic and Social Planning

20A. Population control and Family Planning

29. Prevention of the extension from one state to another infections or contagious diseases or pests affecting men, animals or plants

31. Shipping and navigation on inland waterways as regards mechanically propelled vessels

36. Factories

37. Boilers

The Department of Environment has two bodies i.e. (NCEP and National Development Board) to assist and advice the functions of the following bodies; Botanical Survey of India, Zoological Survey of India, Central Board for Prevention and Control of Water Pollution and National Museum of Natural History function. There are about 30 major enactments related to protection of environment being administered by the central and state governments. The Water (Prevention and Control of Pollution) Act, 1974, the Factories Act and the Insecticides Act are some of the prominent ones among these enactments. These Acts are implemented through several organizations like the Central and State Pollution Control Boards, chief inspectors of factories and insecticides

inspectors of agriculture department. In spite of several organizations functioning in the field, industrial accidents have led to widespread concern regarding the danger to environment from hazardous substances. The existing laws to cover such hazards do not provide clear focus of authority to prevent or limit the damages.

In view of many lacunae in the existing Indian laws related to environment protection, a new Environment (Protection) Bill was passed on 8th May 1986, to overcome some of the problems for coordination, implementation and enforcement. The Environment (Protection) Act (EPA), in essence, is an enabling statute seeking to provide for the protection and improvement of environment. It also aims at implementing the decision of the United Nations Conference on Human Environment (Stockholm, 1972). The Act has adopted a very wide definition of environment and its pollutants. It specifically gives power to the Central Government to take all such measures for the purpose of protecting and improving the quality of the environment and preventing, controlling and abating environmental pollution. Accordingly, the Act enumerates a variety of subjects, including quality standards, maximum permissible concentrations of pollutants and location of industry, which the central Government may regulate for the purpose. Thus the EPA extends government control beyond air and water pollution to include other possible polluted media too. It specifically defines hazardous substances, as a regular or distinguished from ordinary pollutants? The department of Environment will also be well advised to constitute the relevant authority or authorities, to speed up enforcement of the EPA. It is also important to ensure proper coordination between the existing machinery and such authority, which will come into being, apart from avoiding overlapping and conflict of jurisdictions.

The Planning Commission set up an expert committee to formulate long-term sectoral including environment and forest policies. The Planning Commission suggested eight major tasks:

1. To protect the natural environment
2. To regenerate and restore degraded ecosystem and increase their productivity, and to generate employment through these activities
3. To decentralize control over nature and natural resources
4. To develop and disseminate an understanding of nature and natural processes

5. To formulate a national policy for the environment and design an appropriate institutional and legal framework in support of the policy
6. To ensure coordinated and integrated government action aimed at conserving nature and making sustainable use of natural resources
7. To make individuals and institutions more accountable for any action impinging on the environment and the ecosystem
8. To monitor the state1ofthe environment

5.44 TIWARI COMMITTEE (1980)

The Government of India set up a committee in January 1980 under the Chairmanship of Shri. N.D. Tiwari, then Deputy Chairman of the Planning Commission to review the existing environmental legislations and recommend legislative measures and administrative machinery for environmental protection. The committee stressed the need for the proper management of the country's natural resources of land, forest and water in order to conserve the nation's ecological bases.

The committee's recommendations were

1. Creation of comprehensive environmental code to cover all types of pollution and environmental degradation
2. Constitution of environmental Courts in all district headquarters and appointment of experts to assist the Court
3. Creation of Department of Environment.
4. Setting up a Central Land Commission.
5. Provisions of economic incentives to industries to encourage environment friendly products, income tax and sales tax benefits for adapting cleaner technology, investment tax, credits for purchases of purification devices, replacement cost of purification equipment in annual operating costs and minimal tax or no tax on the manufacture of pollution control devices.

Making environmental impact assessment, not only a prerequisite for industry to start but also repeated periodically.

The emphasis laid in the planning commissions' reports and Tiwari committee's recommendations led the Government of India to set up a separate department namely Department of Environment in the year 1980. To improve the implementation of laws

and policy directives the Department of Environment was replaced by an integrated Department of Environment, Forests and Wild life in the year 1985, which later on expanded into a Ministry namely Ministry of Environment and Forests. The other some important policies were:

1. Ministry of Environment and Forests
2. Establishment of Pollution Control Boards
3. Rio Conference Policy (1992)
4. Indian Environmental Policy (1992)
5. Forest Policy (1988)
6. National Conservation Strategy (1992)
7. Post Stockholm Environmental Legislations

a. The Water (Prevention and Control of Pollution) Act, 1974, as amended by Amendment Act 1988.
b. The Water (Prevention and Control of Pollution) Rules, 1975.
c. The Water (Prevention and Control of Pollution) (Procedure for Transaction of Business) Rules, 1975
d. The Water (Prevention and Control ofPollution) Cess Act, 1977 as amended by Amendment Act, 1991.
e. The Water (Prevention and Control of Pollution) Cess Rules, 1978.
f. The Air (Prevention and Control of Pollution) Act, 1981 as amended by Amendment Act, 1987.
g. The Air (Prevention and Control of Pollution) Rules, 1982.
h. The Air (Prevention and Control of Pollution) (Union Territories) Rules, 1983.
i. The Environment (Protection) Act, 1986
j. The Environment (Protection) Rules, 1986.
k. Environment (Protection) (Second Amendment) Rules, 1999.
l. Forest (Conservation) Act, 1980 as amended by Amendment Act, 1988
m. Forest (Conservation) Rules, 1981.
n. The Wildlife Protection Act (1972) as amended by Amendment Act, 1991.
o. The Public Liability Insurance Act, 1991.
p. The Public Liability Insurance Rules, 1991.

q. The National Environment Tribunal Act, 1995.

r. The National Environment Appellate Authority Act, 1997.

5.45 OTHER ENACTMENTS WITH ENVIRONMENTAL CONCERN

Apart from the above Acts, Rules and Notifications there are other enactments which contain few sections on the protection of Environment and prevention of pollution, they are:

1. Code of Civil Procedure, 1908
2. The Factories Act 1948 as amended by Amendment Act, 1987
3. Industries (Development and Regulation) Act, 1951
4. Mines and Minerals (Regulation and Development) Act, 1957
5. The Merchant Shipping Act, 1958
6. Atomic Energy Act, 1962
7. The Insecticides Act, 1968
8. Monopolies and Restrictive Trade Practices Act, 1969
9. Code of Criminal Procedure, 1973
10. The Indian Coast Guards Act, 1978
11. Motor Vehicles Act, 1988
12. Central Motor Vehicles Rules, 1989

5.46 DEPARTMENT OF ENVIRONMENT

The Department of Environment was created in 1995 as the Nodal Department for dealing with environmental management of the State. The Department of Environment (DoE) is the nodal Agency for planning, promotion, coordination and overseeing the implementation of all the aspects of environment other than those dealt with Tamil Nadu Pollution Control Board.

5.47Aims and Objectives

1. Implementation of National River Conservation Plan (NRCP) for the abatement of pollution in Cauvery, Vaigai, Tamirabarani rivers and Chennai City waterways.
2. Implementation of National lake Conservation Plan (NLCP) for the abatement of pollution in the selected lakes.
3. To carry out various environmental awareness programmes for school students, through National Green Corps (NGC) and Eco-Clubs.

4. To enforce the provision of the Coastal Regulation Zone (CRZ) notification.
5. To provide web-based environmental information through Environmental Information System (ENVIS) on State of Environment and related issues of Tamil Nadu
6. Preparation of State of Environment (SoE) Report, SoE Atlas, SoE Video and Photo Catalogue of Tamil Nadu.

5.48 POLLUTION CONTROL BOARD (PCB)

The Tamil Nadu Prevention and Control of Water Pollution Board was constituted by the Government of Tamil Nadu on twenty seventh day of February, Nineteen eighty two (27-2-1982) in pursuance of the Water (Prevention and Control of Pollution) Act, 1974 (Central Act 6 of 1974). The Board was later renamed as Tamil Nadu Pollution Control Board (TNPCB) in the year 1983. It enforces the provisions of the Water (Prevention and Control of Pollution) Act, 1974, the Air (Prevention and Control of Pollution) Act, 1981, the Environment (Protection) Act, 1986 and the rules made under these Acts, which includes.

1. The Water (Prevention and Control of Pollution) Act, 1974
2. The Tamil Nadu Water (Prevention and Control of Pollution) Rules, 1983.
3. The Air (Prevention and Control of Pollution) Act, 1981
4. The Tamil Nadu Air (Prevention and Control of Pollution) Rules, 1983.
5. The Environment (Protection) Act, 1986
6. The Environment (Protection) Rules, 1986
7. Manufacture, Storage and Import of Hazardous Chemical Rules, 1989
8. Fly Ash Utilization Notification 1999
9. The Batteries (Management and Handling) Rules, 2001
10. The Environment Impact Assessment Notification, 2006
11. The Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016
12. The Bio-Medical Waste Management Rules, 2016
13. The Solid Waste Management Rules, 2016
14. The Plastic Waste Management Rules, 2016
15. The E-Waste Management Rules, 2016

16. The Construction and Demolition Waste Management Rules, 2016

5.49 Functions of Tamil Nadu Pollution Control Board (TNPCB)

The main functions of the TNPCB under the provisions of the Water (Prevention and Control of Pollution) Act, 1974 and the Air (Prevention and Control of Pollution) Act, 1981 are as follows.

1. To plan a comprehensive programme for the prevention, control and abatement of water and air pollution.
2. To advise the State Government on any matter concerning the prevention, control or abatement of water and air pollution.
3. To collect and disseminate information relating to water and air pollution and the prevention, control or abatement thereof.
4. To inspect sewage and trade effluent treatment plants for their effectiveness and review plans, specifications for corrective measures.
5. To inspect industrial plants or manufacturing process, any control equipment and to give directions to take steps for the prevention, control or abatement of air pollution.
6. To inspect air pollution control areas for the purpose of assessment of quality of air therein and to take steps for the prevention, control or abatement of air pollution in such areas.
7. To lay down, modify or annual effluent standards for the sewage and trade effluents and for the emission of air pollutants into the atmosphere from industrial plants and automobiles or for the discharge of any air pollutant into the atmosphere from any other source.
8. To evolve best economically viable treatment technology for sewage and trade effluents.
9. To collect samples of sewage and trade effluents and emissions of air pollutants and to analyze the same for specific parameters.
10. To collaborate with Central Pollution Control Board in organizing the training of persons engaged or to be engaged in programme relating to prevention, control or abatement of water and air pollution and to organise mass education programme relating thereto.

11. To perform such other functions as may be prescribed by the State Government or Central Pollution Control Board.

5.50 CENTRAL POLLUTION CONTROL BOARD (CPCB)

The Central Pollution Control Board (CPCB), statutory organisation, was constituted in September, 1974 under the Water (Prevention and Control of Pollution) Act, 1974. Further, CPCB was entrusted with the powers and functions under the Air (Prevention and Control of Pollution) Act, 1981. It serves as a field formation and also provides technical services to the Ministry of Environment and Forests of the provisions of the Environment (Protection) Act, 1986. Principal Functions of the CPCB, as spelt out in the Water (Prevention and Control of Pollution) Act, 1974, and the Air (Prevention and Control of Pollution) Act, 1981, (i) to promote cleanliness of streams and wells in different areas of the States by prevention, control and abatement of water pollution, and (ii) to improve the quality of air and to prevent, control or abate air pollution in the country.

Air Quality Monitoring is an important part of the air quality management. The National Air Monitoring Programme (NAMP) has been established with objectives to determine the present air quality status and trends and to control and regulate pollution from industries and other source to meet the air quality standards. It also provides background air quality data needed for industrial siting and towns planning. Besides this, CPCB has an automatic monitoring station at ITO Intersection in New Delhi. At this station Resirable Suspended Particulate Matter (RSPM), Carbon Monoxide (CO), Ozone (O3), Sulphur Dioxide (SO2), Nitrogen Dioxide (NO2) and Suspended Particulate Matter (SPM) are being monitored regularly. This information on Air Quality at ITO is updated every week.

Fresh water is a finite resource essential for use in agriculture, industry, propagation of wildlife & fisheries and for human existence. India is a riverine country. It has 14 major rivers, 44 medium rivers and 55 minor rivers besides numerous lakes, ponds and wells which are used as primary source of drinking water even without treatment. Most of the rivers being fed by monsoon a rain, which is limited to only three months of the year, run dry throughout the rest of the year often carrying wastewater discharges from industries or cities/towns endangering the quality of our scarce water resources. The

parliament of India in its wisdom enacted the Water (Prevention and Control of Pollution) Act, 1974 with a view to maintaining and restoring wholesomeness of our water bodies. One of the mandates of CPCB is to collect, collate and disseminate technical and statistical data relating to water pollution. Hence, Water Quality Monitoring (WQM) and Surveillance are of utmost importance.

5.51 Functions of Central Pollution Control Board (CPCB)

1. Advise the Central Government on any matter concerning prevention and control of water and air pollution and improvement of the quality of air
2. Plan and cause to be executed a nation-wide programm for the prevention, control or abatement of water and air pollution;
3. Co-ordinate the activities of the State Board and resolve disputes among them;
4. Provide technical assistance and guidance to the State Boards, carry out and sponsor investigation and research relating to problems of water and air pollution, and for their prevention, control or abatement;
5. Plan and organise training of persons engaged in programme on the prevention, control or abatement of water and air pollution;
6. Organise through mass media, a comprehensive mass awareness programme on the prevention, control or abatement of water and air pollution;
7. Collect, compile and publish technical and statistical data relating to water and air pollution and the measures devised for their effective prevention, control or abatement;
8. Prepare manuals, codes and guidelines relating to treatment and disposal of sewage and trade effluents as well as for stack gas cleaning devices, stacks and ducts;
9. Disseminate information in respect of matters relating to water and air pollution and their prevention and control;
10. Lay down, modify or annul, in consultation with the State Governments concerned, the standards for stream or well, and lay down standards for the quality of air; and
11. Perform such other function as may be prescribed by the Government of India.

Advise the Governments of Union Territories with respect to the suitability of any premises or location for carrying on any industry which is likely to pollute a stream or well or cause air pollution; Lay down standards for treatment of sewage and trade effluents and for emissions from automobiles, industrial plants, and any other polluting source; Evolve efficient methods for disposal of sewage and trade effluents on land; develop reliable and economically viable methods of treatment of sewage, trade effluent and air pollution control equipment; Identify any area or areas within Union Territories as air pollution control area or areas to be notified under the Air (Prevention and Control of Pollution) Act, 1981; Assess the quality of ambient water and air, and inspect wastewater treatment installations, air pollution control equipment, industrial plants or manufacturing process to evaluate their performance and to take steps for the prevention, control and abatement of air and water pollution.

As per the policy decision of the Government of India, the CPCB has delegated its powers and functions under the Water (Prevention and Control of Pollution) Act, 1974, the Water (Prevention and Control of Pollution) Cess Act, 1977 and the Air (Prevention and Control of Pollution) Act, 1981 with respect to Union Territories to respective local administrations. CPCB along with its counterparts State Pollution Control Boards (SPCBs) are responsible for implementation of legislations relating to prevention and control of environmental pollution.

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