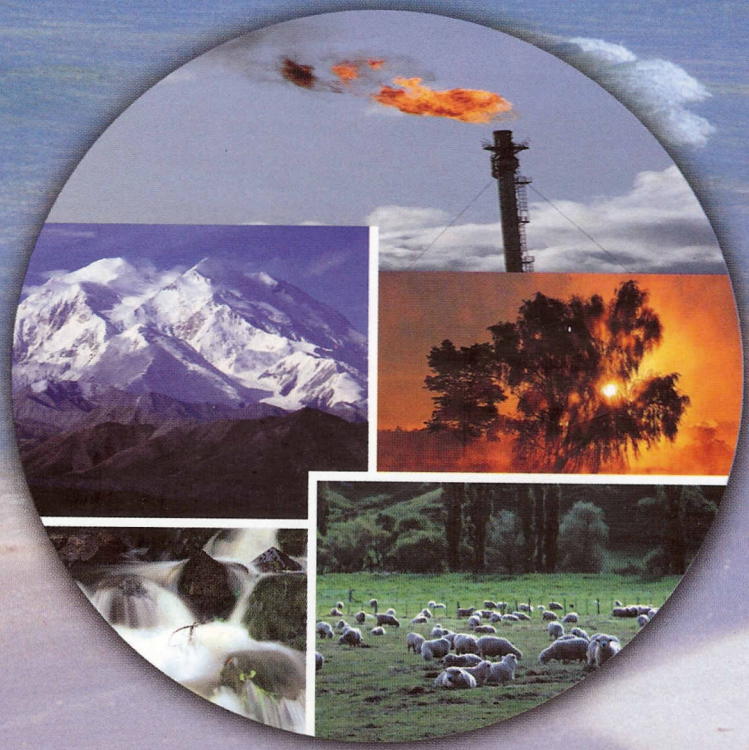
Environment and Natural Resources

Ecological and Economic Perspectives



Editor
O. P. Singh

ENVIRONMENT AND NATURAL RESOURCES

Ecological and Economic Perspectives

Editor

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Regency Publications
New Delhi

ISBN 81-89233-39-4

Published by Regency Publications, 20/36-G, Old Market, West Patel Nagar, New Delhi 110 008 and printed at Radiant Printers, New Delhi 110 008.
Phones: 4248 4101, 5546 2898; Telefax: 2588 4571

Email: regency@satyam.net.in • www.regency-books.com

PREFACE

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

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

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

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

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

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

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

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

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

O.P. Singh

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ABBREVIATIONS

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

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

SECTION ONE

Environment, Natural Resources and Environmental Economics

Chapter 3

VALUATION OF ENVIRONMENTAL GOODS AND SERVICES

S.K. Mishra

INTRODUCTION

Ever-increasing population and its wants that have been growing at an exponential rate have jointly exposed the 'free gifts of nature' to an alarming degree of exploitation. In the last three centuries or so, man thought that these free gifts of nature, the land, the minerals, the waters, the forests, nay, the entire ecosphere is meant for him and his likes alone and these free gifts of nature are indestructible. The enthusiasm spurred by the industrial revolution and the triumph of science and technology has been mainly responsible for such an irresponsible attitude of mankind towards the environment.

Only recently we have realized that the gifts of nature are neither free nor indestructible. Every utilization of environmental resources increases the entropy and thus increases the cost of other operations and products. In the global sense, therefore, no utilization of natural resources is 'free'. Secondly, certain natural resources are regenerable, but many others are exhaustible. All of them are vulnerable to degradation by careless or excessive exploitation.

The objective of the present discourse is to discuss various methods that are suggested or applied to find a pecuniary measure of the worth of environmental goods and services and evaluate them. In a larger perspective, the preoccupation of obtaining a pecuniary measure of something tangible or intangible suffers from many drawbacks, but (traditionally) economists have chosen to stick to that. Moreover, the methods that we are going to discuss suffer from an additional flaw of assuming that "the desired" and "the desirable" are identical. This is a serious flaw that we inherit from the Benthamites, J.S. Mill in particular. We must keep aware of these (cultural, ideological and methodological) biases of economists in the back of our mind while discussing what follows. We will look at the issue from the viewpoint of institutionalism. Institutionalism is an approch that does not limit the study of human economic endeavours from the exclusive viewpoint of market-based economics.

To appreciate the institutionalistic viewpoint one must conceive of an economy as an organism (rather than a mechanism) with close connection with the ecology. Environmental goods and services are the biogeochemical processes, attributes or the products thereof that relate to the self-maintenance of an ecosystem, provision of wildlife habitat, cycling of carbon, nitrogen, phosphorus, sulphur, water or the trapping of nutrients, etc. and make the basis of sustenance as well as prosperity to the human society. Only some environmental goods and services have markets, and therefore, prices of only a few of them are available as data. These prices too, are only the indicators of the minimal payments at which the consumers and the producers have agreed to enter into transactions. At these prices, there may be substantial consumer and/or producer surpluses that may go unaccounted. The worth of environmental goods and services include these unaccounted surpluses, but their prices do not generally reflect their worth. However, a greater part of environmental goods and services have no markets and, therefore, no prices at which they are available to the consumers. Valuation of such goods and services is much more relevant.

Environmental goods and services are often public goods, which to some extent, may be harnessed by many without adversely affecting each other's interest. However, these goods and services have a limit to their bearing capacity, beyond which they cannot sustain their use. Crowding on their use can decrease users' utility. Public goods often suffer free-riders' problem. Although each user values them, none has an incentive to pay to maintain them. These goods and services may also be affected by externalities, or uncompensated side effects of human actions. Market mechanism cannot often regulate their consumption, production and allocation. That necessitates a collective action for their upkeep, which incurs considerable public cost. Hence, the valuation such goods and services may help the resource managers to deal with the effects of market failures, by measuring their social and opportunity costs. The costs to society can then be imposed, in various ways, on those who are responsible, or can be used to evaluate and regulate environmental impacts.

In what follows, we will first describe the methods suggested or applied for pecuniary valuation of environmental goods and services. Then we will assess them on certain principles of institutional economics. Subsequently, a tentative scheme for non-pecuniary valuation of environmental goods and services is proposed below:

ALTERNATIVE METHODS OF VALUATION OF ENVIRONMENTAL GOODS AND SERVICES

Methods of valuation of environmental goods and services may broadly be classified into two categories: (1) Pecuniary, and (2) non-pecuniary. Pecuniary valuation methods obtain the 'money equivalent' of these goods and services — money is used as the numéraire, while non-pecuniary methods, more general in nature, may use any numéraire for valuation. Our primary concern here is to discuss only the methods of pecuniary valuation. These (pecuniary) methods may again be classified into three: (i) based on Market Prices or Revealed Willingness to Pay, (ii) based on Circumstantial Evidence or

Imputed Willingness to Pay, and (iii) based on survey of Expressed Willingness to Pay. In each category, there are several alternative methods.

VALUATION ON THE REVEALED WILLINGNESS TO PAY

Whenever an environmental good/service or a product using it as an input has a market, the buyers reveal their willingness to pay, since they buy the good/service at a price. On this principle four methods have been developed. They are: (i) The Market Price Method, (ii) The Productivity Method, (iii) The Hedonic Pricing Method, and (iv) The Travel Cost Method. In this section we discuss them in some detail.

The market price method

This method estimates consumer's surplus and producer's surplus using market price and quantity data regarding the environmental goods/services (e.g., fish, timber) traded in the market. Consumer's surplus is the benefit enjoyed by the consumer over and above the cost that he has paid for commanding them. Similarly, the producer's surplus is the benefit that he enjoys over and above the cost that he has incurred in producing and marketing the output. The total net economic benefit, or economic surplus, is the sum of consumer surplus and producer surplus. Environmental goods and services that generate larger net surplus are more valuable.

This method has several limitations. First, since only a few environmental goods/services are bought and sold in the markets, its coverage is limited. Secondly, market imperfections distort prices and, therefore, the efficacy of such prices in measuring the net benefits. Prices also vary seasonally and cyclically. Further, the ambit of market economy depends on the level of development of an economy. In less developed economies many resources that contribute to the produce brought to the market go unaccounted and thus are not reflected in the prices.

It may also be noted that estimation of net economic benefits depends on estimation of consumer and producer surpluses, which in turn, depends on the specifications of the demand and the supply curves. Depending on the specification, the functional relationships between demand, supply and their determinants may be overwhelmingly complicated or too simple. The functional relationships may be linear or non-linear, bivariate or multivariate and so on. The list of determinant variables (such as income, prices of substitutes, prices of other goods, etc.) may not be an easy task to make. Due to all these, the estimation of consumer as well as producer surplus will be model dependent. Consequently, the estimated net benefits also would be model dependent.

Productivity Method

This method is applicable in cases where the environmental goods/services are some (or one) of the inputs to produce a marketed good. An appropriately specified production function may indicate the contribution of these inputs to the output and from this information one may deduce the benefit due to these inputs. This method requires that data must be collected regarding how changes in the quantity or quality of the environmental resource affect — (i) costs of production for the final good, (ii) demand for and supply of the final good, (iii) demand for and supply of other factors of production. This information is used to link the effects of changes in the quantity or quality of the resource to changes in consumer surplus and/or producer surplus, and thus to estimate the economic benefits. However, not all environmental goods/services are related to the production of marketed goods. This fact limits the scope of application of this method. In making policies, one has to understand the relationships between actions to improve quality or quantity of the resource and the outcomes of those actions. These relationships are not obvious. If the changes in the availability, quantity and quality of environmental goods/services affect the market price of the final good, or the prices of any other inputs, the method is

difficult to apply. Specification and estimation of a suitable production function is not an easy task. Moreover, the very concept of production function presumes optimal utilization of inputs, which, in the real life is not always feasible. There are many obstacles to optimal utilization of inputs, such as X-efficiency, moral hazards, premium for uncertainties, robust local optima, rational ignorance and so on. It has also been pointed out that activity analysis, rather than production functions, give a true picture of the relationship between inputs and the output. If activity analysis of production process is carried out as a background to productivity method of valuation, a better and more reliable valuation would be possible.

Hedonic pricing method

Consider a (marketed) good/service as a bundle of characteristics (as Lancaster has suggested). The producer enriches his product with the characteristics in demand (and some more that may induce product differentiation and/or cover the demand of a larger or heterogeneous clientele). A buyer has a demand for a number of these characteristics (may be, not all characteristics that the said bundle possesses) and pays for them. A diminution in the desired characteristics will lower the demand for the bundle (good/service) and thus will affect its price adversely and vice versa. In this vein, some marketed products are tied with some environmental goods/services. When a person buys those goods/services, he also buys the environmental goods/services tied with them. The buyer pays not only for the marketed goods/services, but also for the package that includes the tied up environmental goods/services. A diminution of environmental goods/services, therefore, degrades the package and lowers its price. This fact is used by the hedonic pricing method for valuation of environmental goods and services. Therefore, this method is most suitable to assess the value of local environmental attributes. It is used to estimate economic benefits or costs associated with environmental quality, such as air pollution,

water pollution, or noise, and environmental amenities, such as aesthetic views or proximity to recreational sites, etc. These attributes directly affect house rents and land prices in a locality. From changes in house rent or land prices, the valuation of environmental attributes is done.

This method is applicable only to valuation of those environmental goods/services that are tied to a marketed goods/services and the prices of the latter respond to changes in the quality/quantity and attributes of the former. It is also assumed that nothing else modifies the relationship between them. Further, this method demands a rich data base and reliable estimation method. It is also susceptible to the choice of model specification used to estimation at hand. A wrong specification of the model or the method of estimation may easily underestimate or overestimate valuation of environmental goods/services.

Travel cost method

The travel cost method is based on the assumption that the cost that people incur to visit a site is the payment or the "price" of access to the site and its environmental services. It may be measured in the money value of time as well as the cost of journey. Peoples' willingness to pay to visit the site may be estimated based on the number of trips that they make at different travel costs. The travel cost method is often used to estimate economic use values of recreation spots or sites, effects of changes in access costs for a recreational site, elimination of an existing recreational site, development of a new recreational site and addition or removal of some environmental services or alterations in the quality of services available at a recreational site. It may also be used to evaluate the location decision of a public service to which many people visit.

The travel cost method is uncontroversial, inexpensive and reliable, but it has its own limitations. Especially, it is difficult to assign pecuniary value to time cost of the visits to a site. If the visits serve many purposes of a visitor, or very different mix of different purposes of different visitors, the method may

cut a sorry figure in estimating the use value of services/characteristics of a site.

VALUATION ON THE IMPUTED WILLINGNESS TO PAY

The value of some environmental services can be measured by estimating people's willingness to pay, or the cost of actions they are willing to take, to avoid the adverse effects that would occur if these services were discontinued, or to replace the lost services or revive the services. Three very closely related methods have been proposed that are based on these considerations. These methods are: (a) Damage Cost Avoided Method, (b) Replacement Cost Method, and (c) Substitute Cost Method. These methods are based on the assumption that, if people incur costs to avoid damages caused by lost environmental services, or replace them in case they are lost, then those services must be worth at least what people paid to maintain or replace them.

Are costs of damage avoidance or replacement of an environmental good/service commensurate with the benefits they provide? Possibly, costs are the lowest limit to the benefits when purely economic considerations are made. Sometimes non-economic considerations dominate the economic ones and in those cases, costs may be overwhelmingly higher than the economic benefits. It is assumed that man is rational (in economic sense of rationality). But in fact, man is so much guided by emotions, feelings, etc. On these considerations, damage avoidance or replacement methods of valuation are best suited only to cases where damage avoidance or replacement expenditures have actually been, or will actually be, made. These are risky and inaccurate methods to use.

VALUATION ON THE EXPRESSED WILLINGNESS TO PAY

As it has been mentioned earlier, many environmental goods and services are not traded in markets, nor are they closely

related to or tied with any marketed goods. Therefore, people cannot "reveal" their willingness to pay for them. Nor it is always possible to impute people's willingness to pay by their action or expressed intent to avoid losing those environmental goods and services or replacing them if they are lost. In such situations, therefore, a survey designed to make the people face an artificial scenario may be carried out. They may directly be asked as to what they would be willing to pay, if that is the hypothetical scenario. In a simulated condition, people can be asked to make tradeoffs among different alternatives. From the data generated by such surveys, people's willingness to pay may be estimated. In a way, these surveys experiment with the people to know their willingness to pay for some environmental goods/services. Based on this scheme, two methods have been suggested. These methods are: (a) Contingent Valuation Method, and (b) Contingent Choice Method.

Contingent valuation method

The name 'contingent' valuation is based on the characteristic feature of this method as it works on asking people to state their willingness to pay, contingent on a specific hypothetical scenario and description of the environmental goods and serviced. It is based on an assumption that people would do what they say. Indeed this assumption makes the foundation of this method rather shaky because the congruence in thinking, saying and doing is not necessary. It is not unusual to experience that in saying people are guided by the 'ideals', but in doing they quite forget the ideals. It is easy said than done, goes the proverb. However, if there is some significant association between saying and doing, this method may be very successful in eliciting the willingness of the people to pay for the environmental goods and services and thus, their value. Therefore, granted that its assumption is correct, the contingent valuation method is a very versatile method which can be applied to valuation of almost any kind of environmental goods and services irrespective of their being marketed or not marketed. It can be used to estimate

use value, non-use (passive) value, option value (reserved for one's future use) or bequest value (reserved for the use by the future generation). On the other hand, it is also the most controversial among the non-market valuation methods, mainly on account of its shaky assumption.

It would be worthwhile to describe the steps to be followed in the application of this method to valuation of environmental goods and services. To begin, the evaluator has to define the valuation problem, describing its nature, relevance, implications, etc. It may be borne in mind that relevance and implications of the valuation problem vis-à-vis the population to be surveyed for eliciting their expressed willingness to pay may be important. It is easier and more natural to express one's willingness to pay for a good or service which one is concerned with than for those goods and services one has no concern, relevance or even meaningfulness. In the second step, the nature and procedure of survey are decided. What would be the mode of obtaining the replies or 'data' on the expressed willingness to pay? Which questions are to be asked? who will be surveyed? What would be the sample size? And such details about the instrument, respondent and procedure of the survey must be carefully determined. These surveys may be quite expensive if the respondents are to be met in person. In such cases, the cost constraints on survey are to be looked into. The instruments and the procedure of survey are to be tested and perfected before they are finally executed. In the next step the actual survey is implemented on the sample respondents chosen by a well-designed sampling method. Finally, the data obtained through the surveys are analyzed to estimate the expressed willingness to pay. In the analysis one may deal with the non-responses suitably.

The outcome of the exercise based on the contingent valuation method may be susceptible to many biases: (i) Biases due to divergence between the intended import (of the evaluator) and received import (by the respondents) of the hypothetical scenario put up in the survey, (ii) Biases due to association of different scenarios with the one put up by the evaluator before the respondents — once the evaluator puts up

a scenario before the respondent, it may invoke other scenarios in the minds of the respondents inhibiting or promoting/boosting up the appreciation of the evaluator's scenario. This may lead to biased responses, (iii) Evaluator's scenario may invoke 'warm glow' effect — feeling good to pay for the public good, or it may dampen the actual response due to political biases evoked by the scenario — thus making the response biased, (iv) Biases due to casual dealing of the respondents with the whole exercise of the survey may be there, (v) If people are first asked for their willingness to pay for one part of an environmental asset and then asked to value the whole asset, the amounts stated may be similar. This is referred to as the "embedding effect." Due to this effect, the responses are biased, (vi) Strategic bias — when the respondent provides a biased answer in order to influence a particular outcome. (vii) Information bias — it arises when people have to express their opinion of something of which they do not know properly. In the application of contingent valuation method, many respondents may not be able to appreciate the problem and their expressed willingness to pay may incorporate this kind of bias. The success of this method lies in drawing conclusions net of these biases. This is a stupendous task.

Although it is claimed that this method is equally effective in obtaining various types of values — use value, non-use value, optional value and bequest value — one must look into the biases that people exhibit between choice of the present over the future and the choice of themselves over the others (their children). The future is uncertain. People experience a sea change in things only in the part of their life time. Uncertainty always costs and this cost is very likely to be incorporated in the values that the respondents express. In using the contingent valuation method, this fact should not be lost sight of.

The contingent choice method

Much like the contingent valuation method, the contingent choice method is a very versatile method, which can be applied

to valuation of almost any kind of environmental goods and services irrespective of their being marketed or not marketed. It can be used to estimate use value, non-use (passive) value option value (reserved for one's future use) or bequest value (reserved for the use by the future generation).

Contingent choice method is also referred to as the conjoint analysis. It was developed in the fields of marketing and psychology to measure individual's preferences for different characteristics or attributes of a multi-attribute choice problem. This method is similar to the contingent valuation. Like the contingent valuation method, it is based on asking people to state their willingness to pay, contingent on a specific hypothetical scenario and description of various environmental goods and serviced of which they have to make a choice. Making choice among different alternatives (environmental goods and services) in a simulated or artificial scenario —rather than directly assigning pecuniary values to the goods/services as done in the contingent valuation method — is the characteristic feature of this method. From the data on contingent choices or trade offs made by the people, values of different (alternative) environmental goods/services are inferred by using different methods. The method elicits information from the respondent on preference between various alternatives of environmental goods and services, at different price or cost to the individual. Suppose, there are five alternative baskets/bundle of characteristics — A, B, C, D and E. They are available at prices P(A), P(B), P(C), P(D) and P(E). The prices may be single or multiple valued. The alternative commodity/service baskets may vary in quantity, quality, structure, coverage or a mix thereof. The full details on these baskets or combinations are given to the respondents. The respondent is made to choose A, B, etc. at different prices. This exercise provides the preference structure of the respondents and associates that structure with the prices.

There are several alternative formats to carry out the contingent choice analysis. Some of them are: (a) ***Contingent Ranking*** — in the surveys individuals are asked to compare and rank alternative action outcomes with various

characteristics, including costs, (b) ***Discrete Choice*** — respondents are simultaneously shown various alternatives and their characteristics, and asked to identify the most preferred alternative in the choice, (c) ***Paired Rating*** — respondents are asked to compare two alternate situations and are asked to rate them in terms of strength of preference. The choices bade by the respondents are statistically analyzed using discrete choice statistical techniques, to determine the relative values for the different characteristics or attributes. Since price is one of the characteristics of the alternatives, the choice is tagged with the pecuniary measure. It is possible, therefore, to compute the respondent's willingness to pay for the other characteristics.

It may be noted that derivation of values from the data on contingent choices is more difficult and demanding than that from the data on contingent valuation. Various methods have been developed for this purpose. A very potent method to this end is the 'Discrete Choice Analysis'. Discrete choice analysis encompasses a variety of experimental design techniques, data collection procedures, and statistical procedures which can be used to predict the choices that consumers will make between alternatives. These techniques apply when consumers have the ability to choose between distinct ("discrete") courses of action.

The contingent choice method is perhaps the most effective method to elicit the expressed willingness to pay for environmental goods and services that may or may not be traded in the market. However, it has several limitations due mainly to the methodology it adopts. First, respondents may find some tradeoffs difficult to evaluate, because they are unfamiliar with them — which may introduce information bias into their choices. Secondly, the respondents may apply very simplified and routine decision rules if the choices are complicated. Thirdly, the complexity of survey, response and analysis grows at least at a quadratic rate with the number of alternatives included in the scenarios. When presented with a large number of tradeoff questions, respondents may lose interest or become frustrated and psychologically inconsistent. On the other hand, by only providing a limited number of

options, the survey may force respondents to make choices that they were not to make otherwise.

VALUATION BY USING SIMILAR BUT EXTRANEOUS INFORMATION

Sometimes it is possible to obtain information on the valuation of environmental goods and services done elsewhere, in similar (or somewhat different) context. It is possible to use that information to valuation at hand. The method that does this is called the **Benefit Transfer Method**. Benefit transfer is often used when it is too expensive and/or there is too little time available to conduct an original valuation study, yet some measure of benefits is needed. It is important to note that benefit transfers can only be as accurate as the initial study. Moreover, since the context or locational attributes of the initial study do not fully match with the exercise at hand, this method is prone to several limitations. Nevertheless, it may provide some measure to the importance and benefits of environmental goods and services.

It may be possible to reinforce or modify the benefit transfer exercise on evaluation by some limited study in the field under consideration. A suitable study that would not require much time and resources may be carried out to obtain some information regarding the valuation problem at hand and in the light of this information, the initial values may be modified. This is very similar to using the values of the initial study (or studies) as a 'prior', which is modified in the light of the new information yielding the 'posterior' values.

A CRITICAL VIEW OF THE PECUNIARY VALUATION METHODS

Although it may be argued that since the environmental goods and services are often public goods subject to the 'tragedy of the commons' and the public bodies/managers in charge of their creation, maintenance and development incur costs that are measured in pecuniary terms, their benefits too must be

measured in pecuniary terms to keep the account straight and intelligible. However, the enterprise of measuring the benefits of such goods and services in money terms has a cultural bias often unnoticed or ignored. Long back, Thorstein Veblen (1899 a), pointed out that prevalence of pecuniary measures in all walks of life is a sine qua non and the characteristic feature of the Leisure class culture. In this milieu, pecuniary emulation, pecuniary standard of living and pecuniary canons of taste and dress preoccupy everyone's mind. Measurement of everything in monetary terms becomes the habit of mind since people cannot understand anything that does not refer to money. This habit enters into the collective unconscious. Valuation of environmental goods and services in pecuniary measures is only an expression of this habit of thought.

Additionally, we may also note that the pecuniary valuation methods assume a constant 'value' of money over time, generations, locations, income groups and individuals. This is a particular type of habit of thought, inculcated by the neo-classical economists, with which we think. This leads to deification of money. Assigning immutability to value of money introduces a serious bias in valuation, especially when the experience suggests that value of money varies over time, among income groups, etc.

We have pointed out the weaknesses of every method described above, irrespective of the fact whether a particular one is based on the revealed, imputed or expressed willingness to pay. Each one is prone to give valuation that may not be sensitive enough to discriminate the less beneficial from the more beneficial. Their standard errors of estimate (interpreted slightly liberally) are so large as to make them insensitive measures of differential values.

It may also be noted that (possibly except the market price method) the pecuniary valuation methods are 'Indirect or proxy methods', which measure value of environmental goods and services indirectly, through some proxy variable. In the productivity method, the price of final good is a proxy variable, while in hedonic pricing method the price of tied good/service works as the proxy variable. In the travel cost method, the

travel cost of visit is the proxy variable. Similarly, in imputed and expressed valuation methods also, valuation of proxy variable is carried out. The mute question is: is there a one-to-one linear relationship in the value of a proxy variable and the value of the 'object variable'? This is a difficult question to answer.

Earlier, we have tentatively hinted at other assumptions that are made to make these methods rest on. To recall, one of the assumptions is to identify the 'desired' with the 'desirable'. Willingness to pay is the measure of the intensity of desire, but not of the status of 'desirability'. There could be a serious and wide hiatus between the status of being desired and that of being desirable. Desires spring from instincts, emotions and habits. Most of the desires are rooted in the culture in which one lives and is brought up. With the economic progress, larger and larger part of desires become culture bound. A leisure class culture characterizes high valuation of conspicuous consumption and conspicuous leisure. Wastage is culturally supported. In this milieu, the desires of the people may suggest the value system that is characteristically wasteful and detrimental to the prudent allocation and use of scarce economic and environmental resources.

We have also seen that the valuation methods based on measurement of expressed willingness to pay assume that what people say they would also do. This assumption is far from being realistic. The divergence between saying and doing may cripple the contingent valuation method. Investigations have shown a considerable inconsistency in pair-wise comparisons of alternatives. Inconsistencies creep in even when the people making choices are dealing with the real world situation. When they are dealing with the artificial choice situation, inconsistencies may be much more alarming. Although it has been attempted to derive consistent and transitive preference pattern from the inconsistent choice data, the results are, in general, far from being satisfactory. Otherwise also, the contingent choice method of valuation has not been put to empirical tests of validity. In this situation, one has to accept the validity of these methods only with a caution.

We may also see that behind all the methods described above, there is a single philosophy that the consumers and their ability to pay determine the value of environmental goods and services. The idea that the consumer assigns meaning to environment and the nature, places man in general and the consumer, his purchasing power and his willingness to spend in particular, in the center. This reflects the attitude of man towards the non-human environment — his sense of the collective power of human communities over the nature. This sense of power, especially underneath the contingent valuation and contingent choice methods, is not very eco-friendly in its nature and impact on human decisions regarding the environment.

A QUEST FOR NON-PECUNIARY MEASURE OF VALUE

As Veblen (1899b) noted "the question of value is a question of the extent to which the given item of wealth forwards the end of nature's unfolding process. It is valuable, intrinsically and really, in so far as it avails the great work which nature has in hand". In this sense, pecuniary valuation of environmental goods and services is ill conceived. It is based on the mechanistic conception of the economy as well as the ecology that houses the economy. The valuation should be based on the organic balance and the position of an environmental attribute vis-à-vis the others in that grand scheme of nature. Looking at the problem in this manner suggests us to evolve non-pecuniary methods of valuation of environmental goods and services.

One may look into the possibilities of non-pecuniary valuation in economic models such as von Neumann (balanced) growth model and others developed along that line. The original von Neumann model of an expanding economy does not include consumption and makes several unrealistic assumptions. Michio Morishima (Takayama, 1974) included consumption into the von Neumann model and by altering some assumptions he made a more realistic model. The von

Neumann-Morishima model of the expanding economy does not include money in it, and therefore, it does not give us prices in pecuniary terms. All the relations in the model are in physical terms. The model gives optimal (non-negative) outputs and prices. With suitable modifications, this model may be used to obtain non-pecuniary values of environmental resources in terms of (say) human labour or any other suitable numéraire.

Operations, expansion and structural changes in an economy and its place in the ecology may be viewed not from the angle of maximization of utility or economic gains, but from the angle of increase in the entropy of the ecological system in which the economy is placed. Increase in entropy over time is unavoidable, but the rate of its increase can be influenced by a deliberate policy implementation. Slower increase in entropy is environmentally desirable. If we chose to minimize the rate of increase in entropy, we have to choose the decision variables suitably (Georgescu-Roegen, 1971). In doing so, we would obtain the non-pecuniary shadow prices of each economic and environmental good/service in terms of entropy in the similar manner as we obtain prices by solving the mathematical model of an economy with an objective to maximize utility or satisfaction. This approach also looks at the economy as an evolving organism than a mechanistic system.

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Chapter 4

LINKING THE SYSTEM OF NATIONAL ACCOUNTS (SNA) WITH NATURAL RESOURCE ACCOUNTING

A.C. Mohapatra

The concept that resources are 'free gifts of Nature' is passé. With rise in world population, explorations and colonisation of every nook and corner of the globe, little remains to be occupied, used and owned that belonged to the realm of Nature. The imprint of man is writ large on every face of Nature and its bounties. Second, there is the general principle; 'what is not owned by the individual or groups, in some cases, belongs to the State'. Thus, the unoccupied mountain tops, or river beds, or the oceanic water (in 'Exclusive Economic Zones' up to 320 km from the sea line) belong to nations through various international treaties; even the mid-oceanic waters and sea floor deposits, or the Antarctic Continent is not spared from national exploration rights and ultimate economic exploitation. Third, many natural resources, whether in nature of goods or services, need regulation by the State, otherwise they are liable to be victims of individual greed; say wood-lands, biotic reserves, wetlands, and such others, could not be left to their

Appendix I

RIO DECLARATION ON ENVIRONMENT AND DEVELOPMENT

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

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

PRINCIPLE 1

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

PRINCIPLE 2

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

PRINCIPLE 3

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

PRINCIPLE 4

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

PRINCIPLE 5

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

PRINCIPLE 6

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

PRINCIPLE 7

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

PRINCIPLE 8

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

PRINCIPLE 9

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

PRINCIPLE 10

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

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

PRINCIPLE 11

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

PRINCIPLE 12

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

PRINCIPLE 13

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

PRINCIPLE 14

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

PRINCIPLE 15

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

PRINCIPLE 16

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

PRINCIPLE 17

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

PRINCIPLE 18

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

PRINCIPLE 19

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

PRINCIPLE 20

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

PRINCIPLE 21

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

PRINCIPLE 22

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

PRINCIPLE 23

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

PRINCIPLE 24

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

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

Principle 25

Peace, development and environmental protection are interdependent and indivisible.

PRINCIPLE 26

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

PRINCIPLE 27

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

Source: UNEP website 2003.

Appendix II

AGENDA 21 INDICATORS OF SUSTAINABLE DEVELOPMENT

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

... contd. Appendix II

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

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

contd...

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

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

Appendix III

LIST OF ENVIRONMENTAL LEGISLATIONS

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

GENERAL ENVIRONMENTAL LEGISLATIONS

1986

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

1986

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

1989

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

1989

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

1989

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

1991

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

1995

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

1997

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

1998

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

LEGISLATIONS FOR PROTECTION OF FOREST AND WILDLIFE

1927

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

1972

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

1980

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

LEGISLATIONS FOR PROTECTION OF WATER RESOURCES AND QUALITY

1882

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

1897

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

1956

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

1970

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

1974

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

1977

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

1978

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

1991

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

LEGISLATIONS FOR CONTROL OF AIR POLLUTION

1948

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

1981

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

1982

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

1982

Atomic Energy Act deals with the radioactive waste.

1987

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

1988

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

GLOSSARY

Abiotic: Nonliving

Abatement: Reduction (Reduction of pollution/emissions)

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

Absolute: A chemical substance relatively free of impurities.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Ambient: Surrounding conditions.

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

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

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

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

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

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

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

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

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

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

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

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

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

Benthic region: The bottom layer of a water body.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Biota: All living organisms of a region or system.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Closed economy: An economy that neither exports nor imports.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Herbivores: Primary consumers; animals that eat plants.

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

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

Humus: Decomposed organic material in soil.

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

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

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

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

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

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

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

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

Incinerator: A controlled chamber where waste substances are burnt.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Noise: Any undesired sound.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Pelagic: Those organisms that swim in open water.

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

Permafrost: Permanently frozen ground.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Resource exploitation: The use of natural resources by society.

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

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

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

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

process removes floating and settleable oxygen demanding substances.

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

Seepage: Water that flows through the soil and rocks.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Water table: The level of ground water.

Watershed: The land area that drains into a stream.

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

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

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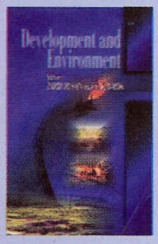
OTHER BOOKS OF INTEREST



Development and Environment

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Currently man is confronted with a perplexing situation related with 'development and environment'. He is surprised to find that the development, a result of his thousands of years of efforts, has become detrimental to the environment — the very base of the development. He is in a dilemma and can't choose only one because he knows that both are essential to sustain human civilisation. Thus, he has to strive hard to strike a balance between the two.

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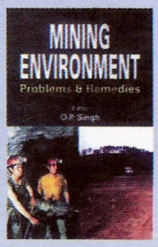

Mining Environment

Problems and Remedies

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Mining is one of the most environment-degrading industries. The adverse environmental impacts of mining operation commence with mineral exploration, extend through extraction and processing and often continue post-closure of the operation. Land degradation, large scale denudation of forest cover and depletion of biodiversity, pollution of air, water and soil and degradation of agricultural land are some of the serious environmental implications of the mining activity. The impacts extend well beyond the mining area and lead to many social, economic and political perturbations. In order to mitigate the adverse impacts of mining and rehabilitate the mining affected areas, it is important to understand various problems of mining environment and their management.

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ISBN 81-89233-39-4
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