

POLLUTION AND ECONOMIC GROWTH

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CHAPTER 1

INTRODUCTION

Man since his origin has lived in harmony with nature through the ages. The Vedas, folklores and scriptures of different civilisations and beliefs also speak of the need for harmony with the nature. Earth is the natural home not only of man but also of all animals, birds, insects, plants and vegetation. In Upanishadas the relationship between man and his environment has been discussed. In order to attain real prosperity, they stressed on complete harmony and interdependence between them.

Truly in the process of living, man was fully dependent on nature. Nature helped man in many ways. With the help of that man is able to develop himself. In the process, he moved towards mechanisation and industrialisation.

Increasing industrialisation and increasing output of the industry to satisfy increasing wants of increasing population has adversely affected natural recycling of various natural raw materials. Prior to industrialisation, human activities affected the ecology in a minor way, but now the output of industry is so large, that the ecology can not remain unaffected. This leads to environmental degradation. This is called pollution. Also the inputs demanded are so vast that natural recycling is not possible. Therefore the available reserves of natural resources have started depleting. It is pretended that the degradation of

environment is an exclusive affair of rich nations, as if it were related only to national income per head, developing countries do not have to worry.

In the last fifteen years or so, most of the developing countries have witnessed a steady increase in environmental degradation and many newly industrialising countries have experienced massive environmental deterioration because of industrialisation and explosive urbanisation.

The capacity of a number of developing countries to manage their environment so as to secure the well being of their people is also coming under severe stress, following the rapid population growth, its uneven distribution and inadequate socio economic development.

The aim of economic activities is to generate economic welfare. One easy way to fulfill that aim is to increase production. The level of gross outputs is a well-known measure of welfare. Conventionally the economy wants to increase welfare, it has to increase the level of production. This is what was done through out the industrialisation process.

Pollution of air and water is a serious problem in most of the countries and imposes considerable costs on the affected areas and persons. The visible effects of pollution are not the only reason to think about the environment. But environmental quality is also linked to a too rapid depletion of the finite natural resources such as minerals and oils and also to the risks of destroying forests and marine life which are in the category of renewable assets. Depletion and destruction of natural

resources are not the results of only excessive rate of consumption, but it can also be the results of other human activities. For example, large scale destruction of forestry may lead to soil erosion which has serious adverse effects on agriculture. Excessive use of chemical fertilizers in agriculture sector may lead to deterioration of ground water quality and using excessive pesticides against harmful insects may have serious effects on ecological system.

Traditionally Gross National Product, (GNP), is at best a rough measure of welfare. Increase in GNP with maintaining quality of life can be a best measure of welfare. An ecological viable increase of welfare, without increase in GNP, as now measured is clearly a logical and perhaps technological possibility.

It is increasingly recognised that GNP is a very poor indicator of welfare. In particular, it does not take into account the negative externalities created in the process of production, such as smoke, effluents, noise etc. But to make things worse, it includes all kinds of expenditure of a more or less compulsory while some people believe that pollution and other negative externalities, could be covered as "negative income" by a broadened concept of national accounts. The research is going on to find some more suitable indicator of welfare other than the per capita GNP.

In the next pages, an attempt has been made to review some of the methodologies, for this measurement of negative impact of pollution and depletion on national income or GNP, and welfare

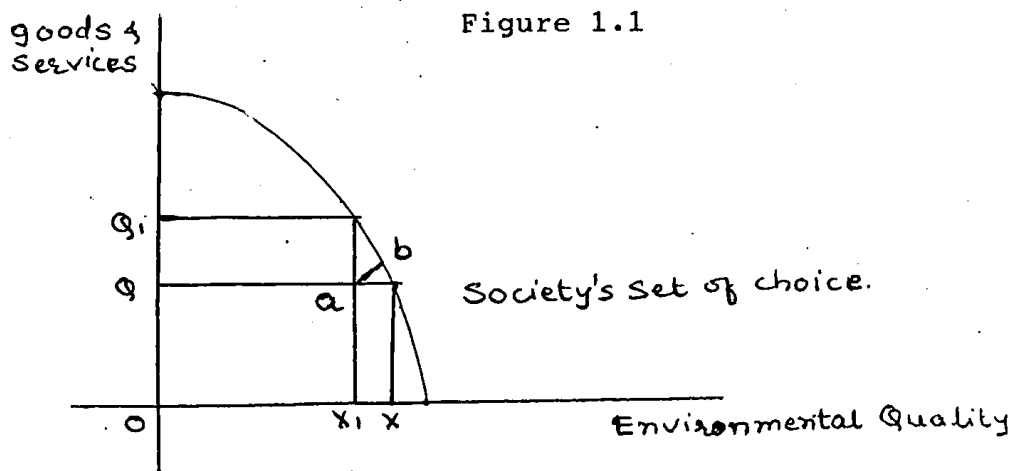
or growth. These measurements have been done at micro and macro levels. At micro, levels input output analysis has been used for determining the gross national product levels, to eliminate pollution.

1.1 WELFARE, ENVIRONMENTAL DEGRADATION AND GROWTH.

The practice of using national product as an indicator of growth is widespread. The country is called rich when it has the largest production. This leads to widespread utilisation and misutilisation of exhaustible resources in the name of modern life style and civilised living. This change in pattern of living at the cost of fresh air and clean water is called the increased standard of living or increasing welfare. An individual's welfare is dependent upon those goods and services he consumes, as well as intangible goods such as environmental services, (carbon dioxide cycles, rain cycles etc). (K. Hajlta, Lindgren).

To get the exact measure of welfare we have to include the cost of consumed environmental services. But the determination of such costs is difficult. Without exogenous interference, it is difficult to determine the relationship between goods and services and quality of life.

It is always very difficult to match the environmental quality and welfare care. Given the present level of technology, a society's production possibility can be described by a curve showing the different combinations of goods and services, on the one hand and environmental quality on the other. The consumer should find the optimal balance between the two.



We can see in the figure 1.1, that as the production of goods and services increases environmental quality decreases.

Production in one sector can have a negative influence on that in another sector. There is lack of communication and also negative externalities. The total volume of production as well as the environmental quality is lower than it would be, if the other sector took in to consideration it's effect on the other. Thus an effective environmental policy can in such cases result in a greater production volume as well as an improved environment. For example, a factory which dumped it's wastes directly into a river, thus increasing the water purification costs for those firms, which are dependent on the clean water for their production. This increase in costs can well be greater than the cost of treating the wastes. The movement from **a** to **b** represents an inefficient use of resources, as it is possible to increase total production, without decreasing environmental quality if the factory processed it's waste material before dumping it into the river.

As national income is determined on the level of goods and services produced, it is also used as a measure of the level of welfare.

1.2. Requirement for the measurements of social welfare

A basic requirement for a measure of social welfare is that it should measure the welfare of society as a whole. ^{(Lindgren} ~~(ibid)~~ Hjalte
Krister Hjalte and others have taken weighted welfare of all individuals in the society, There are two ways to solve the problem.

1. A political welfare function : This function wants to weigh each individual preferences. Thus this function will obviously reflect the ruling persons or party's preferences, for example, the preferences in the socialist countries.

2. The Pareto criterion: This type of social welfare index is usually associated with the Pareto criterion for social changes. This situation represents an improvement for time being not affecting any other person's position.

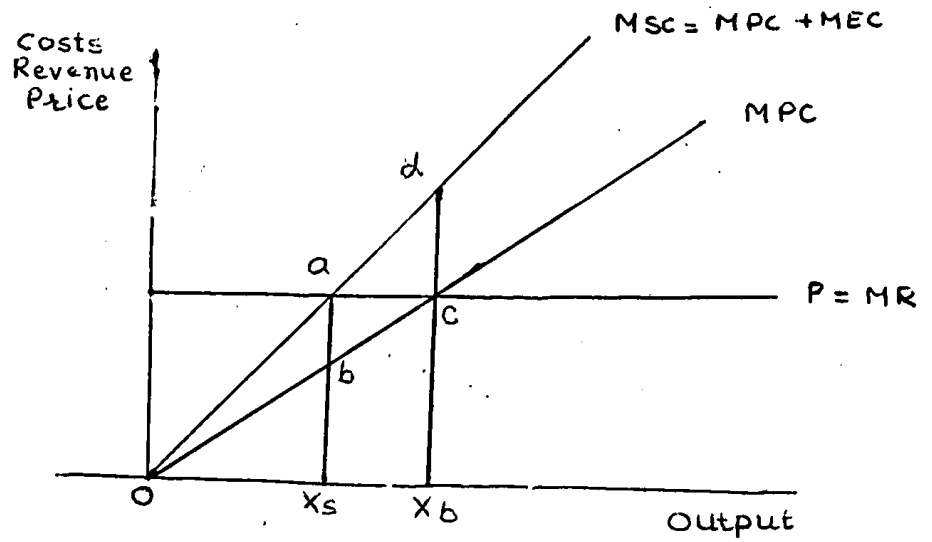
A Pareto optimum is efficient in fulfilling consumer wants. It is the highest welfare position for the society only in relation to the particular distribution of rights to assets which exists. It says nothing about the justice of the distribution of claims. It may generate ecological viable society. (A. Knees).

A decentralized market guided competitive economy will tend towards Pareto optimum when there are no significant externalities. An individual will choose that consumption which

maximises his welfare ^{when} commodity prices ^{are} when income is given. But he can not adjust his consumption of environmental services in the same manner. He must accept the environmental quality as it is. This problem requires a thought of pollution as an external cost and to identify the pareto optimal level of these costs. Invariably this level will not be zero, so that some positive amount of pollution is justified.

Here we have to acknowledge A.C.Pigou, while thinking on welfare, and positive amount of pollution. According to him "The generator of pollution, should be taxed according to the external cost (effluents, smoke etc.) he imposed on others." Such a tax is called a Pigouvian Tax. His work "the Economics of welfare", is a landmark in the development of applied welfare economics, discussed below.

Marginal private costs which differs from marginal social costs by an amount equal to marginal external costs that is, the marginal cost of pollution which is equal to the amount of tax.



At optimum level of output X_p , $MEC = Odc$,

At X_s , $MEC = Oba$, where product price $P = MSC$,

$MR = MPC + MEC$,

Set a tax $=T$, to MEC , we obtain the condition,

$MR = MPC + T$,

Therefore, $MSC = MPC + MEC = MPC + T$.

It will now optimise (maximise) its profits after tax at output X_s , which is the Pareto optimal output. This type of tax and costs also affect the actual level of welfare again. Here tax is a least cost solution to secure a given environmental standard and this result depends on setting the tax level, which induces firms to carry pollution abatement cost function. Assuming some marginal abatement cost function some initial level of tax should be levied and further it should be seen whether it achieves the overall environmental standard laid down, otherwise the tax will have to be changed. So taxing the pollution maker is one way to reduce the level of pollution, but the basic traditional relationship between GNP and welfare could not be ignored. We shall next focus upon those factors which expand GNP and yet their welfare significance is questionable.

Estimation of the total value of goods and services produced for final use, in a particular country is known as the country's gross domestic product. It will be possible in principle to calculate country's gross domestic product, for any period of time, such as a decade or a week. Mostly it is calculated for a year. Here*, Human beings are dependent on nature for resources which are essential to all their productive

activities. Human beings are capable of producing environmental effects qualitatively and quantitatively. Human activities have also introduced artificial radio isotopes, detergents, pesticides, plastics and a variety of toxic metals and gases. These act on the natural environment resulting in adverse effects on ecosystems.

There is a fundamental conflict between the traditional concept of economic growth and the preservation of the environment. During the last century, uncontrolled growth in industrial production of environmentally harmful substances, and products, has produced dangerous amounts of pollution and has been responsible for an inordinate waste of resources.

1.3 Measurement of GNP

The concept of GNP is based on the exchange of goods in market. The other part of this measurement of GNP is money value in market. If one gram of opium has the same value as one kilogram of rice, then these two items are considered as equivalent in national income accounting. Welfare content is concrete, but when it is aggregated into national income or GNP all goods and services acquire a single dimension as market valuation, and the quantitative expression obtained does not

1. Andhra Pradesh Economic Association : Eighth annual conference, Jan. 1990

necessarily relate to concrete welfare content.(S.Tsuru). The idea of a close relationship between GNP and welfare is developed immediately after great depression.

It is now recognised that GNP is a very poor indicator of welfare.It is because it does not take into consideration the negative externalities created in the process of production.For example, smoke,effluents noise etc.The concept of externality is defined by Herfindahl and Allen V.Knees,"Some reasons for these less than perfect operations of the economy are clear.Technological change and changes in consumers taste are disturbing factors that can bring problems of adjustment.Consumption and production are the dependent factors on variable factors.That is,flows of some goods or services that come to consumer or producer whether he wants them or not ,and without his paying for them.These effects are called externalities."(Herfindahl & Knees)

These externalities or environmental degradation should be considered as negative income.Therefore they should be reduced from the broad concept of national income(I.Saches)².

2. Report and working papers of a panel of experts convened by the Secretary General of the United Nations Conference on the Human Environment.(Founex, Switzerland, June,4-12-71.)

Tsuru wants to present the same type of thoughts. He says, "Economist's habits of equating the growth of GNP with that of economic welfare used to be firmly enough grounded." (In Place of GNP).

Since 1970, this type of criticism has been heard particularly from the ecological movement, that the practice of using the national product as a welfare indicator has long been faulted. The environmental damages caused by production and consumption are left completely unaccounted for, in the calculation of national product. They represent additional social costs of production, but they are not recorded as such in the traditional system for measuring the total production of the economy. On the contrary, negative impacts of economic activity, are included in the calculation of national product as positive items in the net production figures of the economy. (C. Leapert).

1.4. Association between growth and environmental problems

There is always a natural association between growth and environmental problems. Many people argue that economic growth leads to increase in pollution.³ Edwin L. Dale, Jr. of the New York Times Magazine, has written, "There are, alas, a few "iron laws" that can not be escaped in the effort to reduce the pollution of

3. New York Times Magazine, April 19, 1970. Page 27. : Edwin D. Dale.

our air and water in disposing of solid waste and the like.....the hard fact is,growth of production is the basic cause of pollution growth." Thus according to Dale, to reduce pollution we have to reduce production.This will create another problem of employment. The law of economic growth tells us that we can not choose to reduce production, simply because we find it to be the cause of fouled environment.He argues for incentives to encourage production with least pollution.He suggests spending for pollution abatement. Technology might be improved to reduce pollution.It is assumed that the mineral resources capacity,food producing capacity of the earth and waste dispersal capacity of the environment, have some fixed limits.

A conference was held by United Nations at Stockhome,in 1972,on" Environment".The representatives of poor nations and poor minorities within developed countries denied that they were consuming too much.Many of them denied that an environmental problem existed at all.Reduction in population growth could give long run relief to these countries.Population growth is also a major cause of environmental degradation, especially when the environmental cure policies are inadequate. This⁴report emphasises the need to manage the consequences of population growth and demographic change and especially the high urban growth rate.

4. The environmental program for the mediterranean :World bank:European investment bank :Chapter 3.

Continuous population growth and also industrial growth will be a dangerous situation to mankind.(Donella).

Some writers claim that these environmental problems are inevitable results of growth in GNP or material living standards.They argue the zero GNP growth is the only alternative to environmental decay. The zero growth of gross national product may ignore possibilities for different forms of growth which would be less destructive of the environment.It has also a close link with the gross national product as it is measured today.Not all growth need necessarily lead to disaster.(M.Edle).

The weakness in the link between GNP and pollution is that not all activities entering into GNP create the same amount of pollution. This is an optimistic view taken by Mathew Edle. What he wants to say is, ten dollars spent on driving a car for pleasure will involve more combustion than ten dollars spent on evening at the theater.A million dollars spent on operation of a jet bomber will cause more pollution than a similar sum spent on parks.

1.5 Impact of growth on balances of Economy

Economic growth also changes the balance between different sectors of the economy and alters the equilibrium points of different markets. When growth takes place there is an increase in production per capita. Thus in this process the prices of different product may change. Growth increases the ability of the economy to produce foods and hence reduces chance of famine.But at the same time, it may lead to a greater

consumption of fuel and the concentration of population in cities, increasing the danger of pollution. It does raise a possibility that different levels of pollution might be possible for the same level of GNP. (D.W. Pearce).

Since the early 1970's such criticisms have been heard from the ecological movements that, "the environmental damages caused by production and consumption are left completely unaccounted for, in the calculation of national product. Environmental damages imply the consumption of environmental assets, that is a part of the nations total wealth and under certain circumstances an irreversible loss of natural resources or a deterioration in the quality of human life and nature." (Economics and environment : Growth, Pollution and social cost : Mathew Edle.)

Pollution problems, as we know are a result of economic growth. They are of lesser importance in the early stages. The transformation of agriculture, the development of industry and the growth of towns are all the integral parts of development. The process of growth and changes in these sectors can be accompanied by adverse side effects. It has been already seen that as the rate of growth is exponential the amount of pollution is also exponential. Regulating the amount of pollution is thus very difficult. At the same time adopting zero GNP growth is also illogical. There should be positive growth, without pollution. This is not impossible. Because not all activities entering into GNP create equal amounts of effluents, or use equal quantities of resources. Current methods of production may

be imposed by recycling or other new technologies. An increase in national income is often called economic growth. It is identified with increased welfare and assumed as an indicator of welfare. However this terminology is incorrect for a number of reasons. One of these, is that, the increase in national income may be accompanied, by the degradation of a vital scarce good :the environment. The Gross Domestic Product is concerned with production activities alone, this does not take cognizance of it's impact on the environment. (S.E.Serafy, E.Lutze)

The environment is being endangered because economic policy stresses the increase in production as measured by national income. But it neglects to account for the depletion of natural resources and damage to environment. This depletion in turn endangers sustained economic development. (R.Hueting).

1.6. Depreciation and Depletion

As we know, when any new capital accumulation takes place for the new industry or for the same industry there is always a thinking of depreciation. In capital accounts of any industry profits are split into two components: Depreciation and Other.

Depreciation is a notion which explains the rate of capital consumption, over a period of time, it is a notion of recovery of capital. (K.Hjalte, K.Lindgren)

A machine is a capital good, having fixed years of productivity life. After that the producer has to replace it or get it renewed. That is why he (entrepreneur) divides the cost of the machine by the life and gets the depreciation cost per year.

While using the notion of depreciation the idea behind it is that of replacement of that machine. The machine can be replaced within fixed countable years.

But at the same time, the producer will consume some natural resources or some environmental services for which no depreciation cost has been kept aside. The natural resources are non replaceable. But the notion of depreciation is not applied easily to them because these resources are the free gifts from the nature. The idea of depreciation is applied to the machinery because it is bought from somebody at certain cost. But use of natural resources or environmental services, are free and none of the producers is conscious that the resources get exhausted. None of these are replaceable; within short time or some countable years. They take ages to replace. Therefore the consumption of natural resources, results in "depletion".

1.6.1 Depletion

The concept of depletion is that counterpart of depreciation, which is normally applied in extractive industries. Traditionally land has been regarded as a non depreciable assets, yet mineral rights have most often been viewed as attached to the land. The special term depletion thus applied to the special circumstances where land loses value through a process of extraction of some non reproducible element in the soil or sub soil. (D.W. Pearce).

In the developing countries, forests are being rapidly felled for firewood and to permit increased food production, as well as to meet the demand from industrialized countries. The

resulting loss of soil through unstabilised water flow and the degradation of soil caused by inappropriate irrigation are matters of concern. Forest depletion and soil degradation in the developing countries, are probably proceeding so fast as to be probably irreversible. If they continue not only will poverty get worse but the whole mankind will be affected. It is because there is an accelerated build up of carbon dioxide, food shortage, resource depletion and extinction of animal plant species. Remedial measures for maintenance of a minimum livelihood such as a regulatory legislation, is feasible only in the industrialised countries. (OECD 81, Okita).

The notion "percentage depletion" was developed in 1928, in the case of oil and gas. Coal, metals and sulfur were added in 1932. Fluorspar, rock asphalt and ball saggar clay came into the list in 1945 and finally in 1954 percentage depletion treatment was extended to all other minerals. This works as a subsidy to extraction rather than exploration. (A. Biswas).

1.6.2 Weakness of the depreciation approach.

The capital consumption or depreciation approach to treat income from depletable mineral resources. As the resources are depleted by the quantity of extraction during the year the amount of depletion valued at current prices can be deducted from the gross products. For example the depreciation of capital equipment used for manufacturing is subtracted from the gross value added by manufacturing activities. The mineral extraction earnings can still be reckoned in GDP, provided that the value of

depletion is deducted from it for calculating net income. The problem of the exact valuation of capital consumption in this case appears to be of secondary importance.(Serafy S.E.).

When we look after the economic performance of the nation we often look at the growth of GDP (Gross Domestic Product) per head. The problem with this index is that its figure for any given year offers no indication of future production prospects.

1.7 Depletion and National Income

The concept of Net National Product takes precisely this into account. NNP as customarily estimated, concentrates on depreciation of manufactured capital. It does not recognise environmental capital assets, that is stocks of natural non renewable resources. All production and consumption activities are based ultimately on natural resources.

As matters stand, estimates of Net National Products are based on the assumption that environment and natural resources on site are all free goods. Consequently these estimates are biased. Moreover it is also certain that almost all the growth rates of NNP as customarily measured are higher than what in fact they are. This is because there is overwhelming evidence that in the aggregate, environmental resources are currently being depleted in quality and in quantity, or in both.

In general the treatment of defensive expenditures for national accounts assume greater significance, the higher the degree of industrialisation of the country concerned. In contrast,

depletion and degradation are not directly related to the level of industrialisation but are particularly important for countries that base their economic activities on the exploitation of their natural resources. Defensive expenditures considers only unwanted side effects of production and consumption, but not those relating to national security. (ibid).

1.7.1 Defensive Expenditures

Leipart, Defines defensive expenditures, "The term is understood to mean outlay with which the attempt is made to eliminate, mitigate, neutralize or anticipate and avoid dangers and deterioration that the economic process of industrial societies has caused to living working and environmental conditions." (Social cost of economic growth : Journal of economic issues: March, 1986.).

"It does not make sense to incorporate expenditures incurred to redress some or all of the negative consequences of production or consumption activities, in the stream of income generator by economic activity. It has been therefor been proposed that such outlays should not be counted as final expenditure as is currently the case, but rather as intermediate expenditure." (Salah EL Serafy, and Ernest Lutz, "Environmental and resource accounting : An Overview.)

When natural resources ,such as water, air and soil used as natural capital, that is drawn down, should be showed as consumption in the measurements of national income, whether or

not defensive expenditures are actually being incurred to correct for the negative effects and restore the drawn down natural capital.

When depreciation is subtracted from GNP and we can get NNP. The same way depletion of natural resources also could get subtracted from GNP to get the real picture of national income.

As most economists know, there are several controversial issues concerning national accounting. Net domestic Product as measured at present, does not adequately represent true income. Sustainable national income is a new concept which deals with environmental protection and the depletion of natural resources.

1.8 Sustainable national income

Two adjustment to NNP are needed. One is simply to extend principle of depreciation to cover consumption of natural capital stocks depleted through production. The other is to subtract defensive expenditure from the unwanted side effects of our aggregate production and consumption. Regrettable defensive expenditures are in the nature of intermediate goods, cost of production, rather than final product available for consumption.

To summarise, let us define the corrected income concept. Sustainable social net national product (SSNNP) as net national product (NNP), minus both, defensive expenditure (DE), and depreciation of natural capital (DNC), thus,

$$\underline{SSNNP = NNP - DE - DNC}$$

Since NNP is a familiar concept, it remains only to discuss briefly the new accounts DE and DNC, which are by no means a novel ideas but are not yet included in as part of national income accounting. (N.E. Dale).

Thus according to Leipart, " When our aim is to, asses the contribution of industrial output to the quality of life experienced by society, then the unidimensional concept of GNP is clearly inadequate. To an extent GNP contains transactions that as such can not be given a positive value and whose activity lies only in their function of repairing damage, brought about by economic activity." (Journal of economic issues : Sep.1989.)

Thus in the first chapter, we have discussed the points concerning with national income and environment, growth and welfare. The impact of growth on welfare etc. In the next chapter qualitative as well as quantitative measures of environmental quality are discussed, both at the micro level as well as macro level.

In the following chapter, the qualitative approach of environmental cost at micro and macro level will be discussed. At macro level or at the globe level pollution that is of air, water etc. will be discussed.

Further, it is intended to discuss the quantitative approach to the micro level pollution cost. That is cost and benefit analysis, along with it's advantages, disadvantages, difficulties in measurements, of the same.

In the next chapter, the quantitative approach at macro level will be discussed. For that, the frame of W. Leontief's Input Output model is used.

The model will be developed on the basis of these reviews and Leontief's article for the global level. An empirical example will be taken. For that a simple 3×3 model for the economy, has been chosen having three sectors, namely 1. primary, 2. secondary, 3. others.

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CHAPTER 2

QUALITATIVE APPROACH TO POLLUTION

2.1 Introduction

The discussion related to the growth, environment and national income related with welfare carried out in the earlier chapter has indicated the importance of studying the pollution in depth. Here an attempt is made to focus the discussion on the qualitative and quantitative measurements of the pollution.

The quantitative measurements of pollution is covered at micro level as well as macro level. The following chapter discussed the qualitative and micro level treatment of pollution in the economy. While the macro level measurements of pollution and its impact on national income is studied in the next chapter.

2.2 Qualitative measurements of pollution

The common definition of pollution usually requires that the pollutant has caused a change in the environment and that this change is harmful. The term "harmful" is also a relative term. "Pollution means the introduction by man, directly or indirectly, of substances or energy into the environment resulting in detereorous effects of such a nature as to endanger human health, harm living resources and ecosystems, and impair or interfere with amenities and other legitimate used of the environment." (OECD 1976 a)

Thus pollution is the term which describes any environmental state created by man, which is harmful or unpleasant to life. It results from man's failure to achieve

or maintain control over the chemical, physical or biological consequences of his technological, industrial, scientific and social habits.

When talking about pollution it is important to consider "actual harm and its time duration."The impact of pollution is not uniform and has different effects on different elements of ecosystem. That is human recipients, plants, animals and physical elements. One can not therefore say that a certain substance is always a pollutant and has some absolute quality of pollution.

The aim of pollution control should be to reduce the harm of potential pollutants. To formulate an economically efficient pollution control strategy, it is necessary to concentrate on damage side. Control of pollution should take into consideration the local use of environmental resources; (rivers, land, sea, air). It is necessary to stress on human activity in the definition of pollution, because disagreeable changes in the environment may also result from natural hazards in the economy, for example, disappearance of fish may be due to changes in sea temperature and climate or over fishing or pollution. Therefore it is important to distinguish between natural causes and human causes. Chandrashekhar, while studying the environmental effects, classified these damages under following five heads⁵.

5. Economics and Environmental perspectives: Eighth annual conference : Jan 1990, of Andhra Pradesh Economic Association.)

1. Resource deterioration: The deterioration for example, of material, soil and forest resources.

2. Biological pollution: The pollution represented by human disease and animal and plant pests.

3. Chemical pollution: arising out of air pollutants, industrial effluents pesticides, metals and detergent components and similar agents.

4. Physical disruption: as reflected by thermal pollution, silting and noise.

5. Social disruption: it is highly essential to pay attention to factors like speed at which environmental degradation takes place. The degree of its severity, the area it covers, whether this impact is reversible or not and at what cost, at what period of time, so as to promote welfare of people.

Within the framework appropriate to the situation, each country may ascertain the nature of its environmental problems and examine alternative forms of action for dealing with them. Especially those damages, which directly affect major objectives like economic growth, should be given the most immediate attention for remedial action.

The above five categories are the main categories of pollution damages. Let us have a detailed look over each of them.

2.2.1. Resource deterioration

The growth of economics in history has allowed production to reach a point at which depletion of resources supplies and pollution, has become a serious problem.

From the natural environment , there is a flow of resources in a very broad sense to production and consumption . For production purposes raw materials and energy are extracted from the environment. Land is used for agriculture, housing or industry. Waters are used for fishing and transportation ,agriculture and provide electricity. The environment also provides goods and services directly for consumption. People use it for recreation and they enjoy natural forests, clean water and rich wild life.

We can increase GNP by replacing resources (savings).But there are some resources which we can not replace (mineral deposits), then the alternative is to find ways of economising their use when the depletion process goes to far. There are other types of social wealths which can be replaced after being used (for example forestry and marine resources). GNP can be raised by depleting such amenities at an exponential rate. (S.Tsuru.)

This part is already discussed in the earlier chapter, while discussing the depletion and it's impact on national income, and to avoid repetition we will the discuss the second.

2.2.2 Biological Pollution

The dangerous problem mankind facing is the poisoning of the atmosphere. Take the example of Bombay,a heavily industrialised city with a high concentration of factories. Every moment Bombayiteis breath air containing so many poisonous chemicals that ten percents more of them suffer from asthama, bronchoitities, cough,cold and headaches than citizens of

almost any other city or town in India. Air pollution is the greatest threat to our health in future. Biological pollution is an effect of all other types of pollution.

The issue of Ozone layer can be studied here, because, depletion of it, may be harmful to mankind.

The Ozone layer.

Ozone is a gas, which is a form of oxygen, is found in the atmosphere of the earth, between heights of twenty and thirty kilometers from the ground the earth's atmosphere is covered by the Ozone layer. A few kilometers thick this layer is spread over the entire globe and shields all things below from ninety nine percent of the Sun's ultra violet rays. Ultraviolet rays can cause skin cancer, and are dangerous to many forms of life. If the ozone layer is reduced this danger might increase⁶.

Moreover scientist believe that the climate on the earth as we know it today is due to the ozone layer. The destruction of this layer could create an effect over the earth very similar to the artificial heat in a greenhouse. A greenhouse's roof allows in the sun's light, but prevents much of the heat inside from escaping. Thus a greenhouse effect over the earth would melt the polar ice and drastically affect the climate everywhere. Many scientists believe that life on earth did not evolve until after the ozone layer was formed.

6. A debate conducted in England on the state of atmosphere
:Edited by Y.J.Ahmad.

One more cause to harm man, animals and plants is soil pollution. The use of insecticides to protect crops has caused serious soil pollution in many parts of the world. For example, D.D.T. the savior of man, destroyed malarial mosquitoes, body louse, house pests and serious crop pests. However as D.D.T. is a chlorinated hydrocarbons and very stable, today the bodies of insects, birds, amphibians, fish and even man show traces of D.D.T. which has accumulated in their tissues. This has resulted in the restriction of the use of D.D.T. in most of the developed countries. More care is now being taken, with rigorous testing of pesticides before they are used for crop protection.(Sheshagiri.)

2.2.3.Chemical pollution

In this category, the study of air, water etc. will be taken in to consideration.Also at the same time, study of industrial effluents, pesticides etc.. also be discussed.

Air and water pollution are not only the results of, production and emissions of residual waste products, but they are also governed by the interactions of the whole series of variables, that is production, population growth and mechanisation, which may react upon each other, but also upon the other elements in the environment. In addition, the actual rate of air and water pollution at any given time is governed by such intervening environmental variables, as wind velocities, and directions, topography temperature stream flows and water temperatures.(Kapp).

Because of industrial smoke, transportation and burning of fossil fuels,exploration of bombs there is creation of air pollution.

In this aspect,three major threats to the atmosphere have been identified⁷ :

1.Amount of Carbon dioxide is increased due to burning fossil fuels and deforestation. Energy trends predict, increasing rather than decreasing use of fossil fuels in the future. As more carbon dioxide accumulates above in the air. Since one of the functions of carbon dioxide is to keep the earth warm , scientist are worried that higher level will cause the planet to get hotter and hotter.It can be result into raising of the sea levels, because raising temperatures could melt the polar ice caps.

Man's activities can upset the balance of nature worldwide,for example, while generating energy heat is directly poured into the atmosphere. The amount of it is large enough to alter the climate in local areas. There are worldwide effects and are very much difficult to measure and forecast.

2. The second problem results, ironically from attempts to dispose of local pollution. Over the years power stations chimneys have become taller and taller. The pollution is now

7. A debate conducted in England: The state of atmosphere :edited by Y.J.Ahmad

swept up into the air , where it may travel thousands of kilometers before being deposited as acid rain in the other countries.

3. The third problem comes from chloro-fluro-carbons (CFC) used as propellants in aerosol sprays and in refrigeration. These may be off-setting the ozone layer, which protects earth from ultraviolet radiation.

Now we can shift to the pollution by water.

Water pollution

This problem is becoming very serious in fresh water because of contamination of water supplies. The discharge of untreated sewage from cities into inland lakes and rivers has a considerable effect on fresh water life. In sea ports, such as Singapore, large number of ships lie at anchor and use the port facilities. The discharge of raw sewage from those ships into the sea, is a serious form of pollution in all the world's sea ports. Oil discharge from ships and refineries also pollute the sea, destroying sea birds and marine life and in general degrading the sea shore. These are only few examples of many common forms of water pollution. (Knees & Shultze)

The water damaging residuals can be divided in to three categories,

- 1) Degradable
- 2) Non degradable
- 3) Persistent

1) Degradable : Wastes are organic residuals upon which bacteria and other micro organisms can feed. Bacteria themselves, and energy (heat) which is gradually dissipated from the watercourse to the air.

Domestic sewage is the most commonly known organic waste, but industrial wastes from the chemical food processing pulp and paper, petroleum refining and other industries, together with the run off from agricultural feed lots are far greater in volume. After they have entered the water, organic wastes begin to break down into their component parts by the action of bacteria. This process uses up dissolved oxygen; in the water.

2) Non degradable : These materials, which are mostly of industrial and agricultural origin. These are not attacked by the stream biota, (plants and animals) and therefore get affected very little once they get into watercourse, that is the stream does not purify itself. They include inorganic substances, such as, inorganic colloidal matter, ordinary salt and the salts of heavy metals. When these substances are present in fairly large quantities, they result in toxicity, unpleasant taste, hardness and especially when chlorides are present corrosion. These residuals can be a public health problem, usually when they enter into food chain.

3) Persistent : These are the best exemplified by the synthetic organic chemicals. Such as some of the pesticides and related substances, for example, chlorinated hydrocarbons they produced in profusion by the modern chemical industry. They enter watercourses as affluents from industrial operations and

also as waste residuals from households and agriculture uses. These substances are termed persistent because stream biota can not effectively attack their complex molecular chains.

2.2.4. Physical disruptions

In this category the study of physical disruption from acid rain, noise pollution, radio active pollution will be discussed.

Acid rain

Acid rain is having a widespread effect in many country's destroying lakes damaging forests, corroding railway lines, eating away at historic monuments and ruining paintwork on buildings. The economic cost of this form of atmospheric pollution can not be actually assessed but certainly runs into a billion dollars a year^a.

Because of these rains, the diversity of life decreases, fog, moss, flourishes organic matters is decomposed more slowly. Productivity is decreased.

Radio active pollution

The fourth aspect is radio active pollution : Because of the increasing use of radio active materials man has to guard against this most sinister of all pollutants. Radio active waste from atomic power station usually have a very long life, and their safe disposal is difficult to achieve. Radio

8. A debate Conducted in England :The state of atmosphere
:Ed.Y.J.Ahmad.

activity is not only destructive to human and animal life, but radiation can also alter the genetic structure of man and other organisms.(Kapp).

Noise Pollution

Noise may be defined as any unwanted or excessive sound in particular, sounds that produce undesired physiological effects on individuals.

In the urban environment, there are four principal sources of noise. 1. Air craft, 2. Industrial operations, 3. Construction activities, and 4. Highway traffic.(J.A.Lee).

The precise health and environmental effects of noise pollution are fully known prolonged noise exposure may cause general personal stress.

2.2.5.Social Disruption

Environment renders many services to man .It is a supplier of resources of great variety.We extract raw material and energy from it. We are fed from it,by cultivating and harnessing land and water. We use it for recreation and enjoy its beauty. It is also a life supporting system . When an ecological system is too , severely damaged , its life supporting capacity is threatened. A seriously polluted area may become inhabitable. On a global level, damage to the ozone layer or increasing carbon -dioxide concentration in the atmospheric may lead to a deterioration in man's living conditions.

Consumption and production activities generates residuals such as smoke, noise, heat smell, waste materials. Some of these residuals go directly back to the environment . Some are exposed to waste management activities, where residuals are treated either to make recycling possible or to transform them in to forms of waste which are easier to the environment to assimilate or to do less harm. Even if the environment has a certain capacity to assimilate waste, modern society produces waste, in such amounts that environmental quality is affected, thus the functions as a resource supplier and as a life support system are also affected. Water pollution may reduce or even destroy fishing opportunities as well as recreational values. The productivity of agricultural production may be adversely affected by air pollution. So the quality of environment and its ability to perform the functions, is disrupted.

Environmental disruption and social cost have long been neglected. It has become urgent to take interest in the framework of this issue. The acute and potential dangers involved in the disruption of our natural and social environment, for human health and well being are now in attraction of world wide political attention.

No doubt that the problem of environmental damages and costs resulting therefrom, constitute one of the most fundamental dangerous issue which mankind ever faced. There is an inter relationship between the various causes of environmental damage.

These are the types of pollution, but various sectors in the economy, create above types of pollution. Pollution created by one sector is not the same as pollution created by other sector. Thus pollution or environmental degradation made by sectors of the economy is also a major issue to be discussed with.

2.3 Sectoral Pollution

Certain factors of production have particular impact on the development of each sector, from which important environmental consequences arise.

2.3.1 Agriculture

Is a type of sector, on which man is dependent from his existence. Traditionally agriculture is labour intensive and independent from external factors other than nature. Modern agriculture relies on considerable infusion of capital and technology. It is more and more relying upon the purchase of industrial management. It concerns with short cycle crops. It is burdened by population increase, which leads to an overtaxing of the carrying capacity of agriculture resources. These causes traditional agriculture to result in environmental damage. For example Rapid soil depletion and increasing infertility of land, chemical control on weeds and pests, use of inorganic fertilisers, mechanisation, all these may damage the succeeding crops.

Fertilisers used in, the land, can deplete the carrying capacity of the land and more stress of it, may lead to run off into water bodies and poisoning the drinking water. (S. MacLeod).

2.3.2 Industrialisation

It has been observed that the industrialized countries invariably face the danger of pollution and therefore loss of welfare. Environmental problems also grow with industrialisation and urbanisation. The major pollutants, due to industrialisation and technical progress are Carbon-dioxide, Phosphates, Mercury, Lead, Oil persistants organochlorine, insecticides and Radio nuclides. The growth and the maximisation of profits and the technological progress, some how comes in the contradiction of the welfare of society. (Y.J.Ahmad).

There is water pollution because of toxic industrial effluents. The task of treating the waste before discharged into the rivers is done by only a few, who can be counted on finger tips. There is air pollution because of industrial sources. Sulfur dioxide, suspended particulates matters and nitrogen dioxide and carbon dioxide are emitted by the smoke from industries.

The problem of industrial pollution is connected with its size and scale of production of the industry. If it is a very large scale producing industry, then along with the above problems, problem of waste disposal also arises.

2.3.3 Mining

The activities, extraction and processing, more intensive in industrialised world. These mineral exploitation stress, managed without regard to environmental considerations depletion of deposits is inevitable.

2.3.4 Energy production

The evolution of energy use as a country develops has interesting environmental consequences. Apart from hydroelectric power, coal is most widely used throughout the developing world. Fuel oil, natural gas and nuclear power represent the energy improvements of the industrial countries. The environmental costs vary from the pervasive particulate matter of lower levels of development through the hydrocarbons, sulfur and nitrogen oxides, to possible radio active emissions at the highest levels. Here air pollution problem is irreversible.

2.3.5 Transport

Transportation poses both environmental problems and choices to the developing countries. possible solutions of both transportation and development patterns designed to preserve environmental quality are then examined. Air pollution and depletion and Ozone layer are the two consequences.

The cumulative characters and the complexity of the sequence of events could be further illustrated by a variety of economic activities, including those of agriculture where erosion, soil depletion, and the use of chemicals constitute the most typical and spectacular examples of cumulative chains of causation. For examples, the ingestion by cows of plants affected by chemical pesticides gives rise to a contamination of milk product and human tissues.

We thus see that the pollution is invaded all the states of matter we are familiar with, solids, liquids, and gas. Not only human beings but even plants trees and animals are affected by

pollution. Petrol or diesel fumes from lorries, buses and cars contain certain chemicals which on coming in contact with sunlight are transformed into poisonous substances can affect sensitive plants like tobacco, tomato, potatoes, some cereals and certain flowers. Smoke from factories which injure cotton and rose plants. Factories processing metal ore produce sulfur dioxide which has destroyed tens of thousands of hectares of timber plantation.

All this sort of discussion may divert our attention from those of social costs which find their expressions in the following phenomena. For example, work injuries and accidents, crowded and inadequate housing conditions, damaging levels of noise, enforced and uncompensated adaptations to structural changes, workmen compensation systems rendered inadequate because of inflation. Monopolistic determination of real estate values and rents in congested urban areas go to the sky.

For this reason, it should be noted, that when we speak of environmental disruption we mean in effect the disruption of man's natural and social environment.

2.4 Social cost of environment and Growth

Implications of environmental disruption and social cost should be taken in to account as a measure of economic growth and development. This is so, because market transactions between firms and households and the resulting flows and moreover do not measure those physical flows and effects which take place outside the market. For example, the disposal of

residual waste and debris by firms and households into the environment from where they come from in the form of physical nuisance and damage, and reduce our well being.

GNP and the derivatives of it are inadequate as measure of the economic growth. We may register persistently high growth rates, but do not take in to account of almost catastrophic rates of environmental disruption as evidence by rising rates of water and air pollution. These are the causes for chronic bronchitis and other diseases increasing levels of noise and bad odore nuisance, higher frequencies of accidents and work injuries etc. The policy of growth guided by inadequate and incomplete indicators of output and income will turn out upon closer analysis to be giving rise to a pursuit of pseudo growth. " In which increases of consumption or investment are made possible not by growth of net production , but at the expense of running down of natural resources in the form of both resources and amenities."(K.W.Kapp).

Christen Leipart has expressed the similar type of views. According to him, the practice of using the national product as a welfare indicator has long been faulted. According to him, "Thus in the age of ecological crisis, the calculation of the national product cumulatively distorts the measurements of macro economic performance in two ways. It not only obscures real costs of production and consumption, but also records the incremental costs of production's negative environmental

effects expressed as additional burdens placed upon private households, enterprises and the state." Here he introduced two terms, (1) Defensive expenditure, and (2) compensatory costs.

The term "defensive expenditures" is explained in detailed in first chapter. Compensatory costs are the regrettable necessities, the purpose of which is either to compensate for past environmental and other damage, or to prevent its occurrence in future.

Social costs of environmental destruction and the accelerated exploration of natural resources have clearly become a center of public attention today. Chernobyl (April 1986), and Bhopal (1984, August) have come to symbolise the risks of modern technology in industrial societies. On the whole, we distinguish among six spheres in which a major ecological and social costs occur. (1) The environment, (2) Transport (3) Housing (4) Security, (5) Health, (6) Work. These spheres are not mutually exclusive. On the contrary they overlap through their systemic linkages which exist between the environment and health and between the environment and transport.

It is difficult to define and measure in full the costs of damages caused by pollution. It seems feasible to identify some of the costs that are already implicitly included in the national accounts. For example pollution related medical expenses in the final expenditures of governments and households as well as outlays for pollution caused repair and maintenance in the intermediate consumption of industries. Although these

expenditures constitute only part of the total damages caused by pollution, they would indicate the success of abatement programs in reducing pollution damage's over a period of time. (D.W. Blades).

R.H. Coase, dealt with those actions of business firms which have harmful effects on others. The factory smoke has harmful effects on neighboring properties. Normally the conclusion is, that, it would be desirable to make the owner of the factory liable for the damage and place a tax on him. but these are inappropriate because the problem won't be solved only by taxing the factory owner, it is reciprocal. It has to be looked at in total and at the margin. Comparing the marginal cost and benefits from both the sides the final result should be to be maximise the value of production.

9. Pollution damages: Pollution causes damages such as sickness and premature death, stunted growth of crops, disappearance of wildlife, corrosion of metals. The national accounts reflects some of those costs of some of those damages in. For **example**, health expenditure by households or Govt., lower labour productivity, higher cost of food production and increased outlays for repairing and maintaining buildings, but they are not explicitly shown as costs of pollution damages.

Thus this discussion throws light on the seriousness of pollution. It is not enough to just recognise the pollution and its hazards, but one has to measure it and reduce it. The solution to the pollution problem can be in two forms.

1. Preventive type and 2. neutralize type.

Prevention of pollution is easy at the micro level by making the changes in the technology or the approach of the project. However at the macro level the pollutants have to be isolated and neutralized. Thus quantitative measurements of pollution has to be carried out both at micro level as well as macro level.

In the next chapter, we will discuss the quantification of the degree of pollution at the micro level, and then macro level.

Quantification at micro level is useful for policy makers. Towards this end we will start with the cost benefit analysis.

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CHAPTER 3

QUANTITATIVE APPROACH TO POLLUTION

3.1. Cost Benefit Approach

3.1.1 Introduction

Cost benefit analysis, attempts to reduce a multi dimensional problem to one of the balancing monetary costs and benefits. It typically attempts to place a market value on pollution. (Pearce).

Thus while undertaking a project, we have to examine it by the way of cost benefit approach. We can study the cost benefit analysis on three levels.

1. Project level: Cost and benefit of that particular project.

2. Activity level: The costs and benefits of that particular activity

3. Social level : The costs and benefits of that particular project or activity at the society level.

To take a rational decision about a single project or a number of projects, we can divide the analytical procedure of Cost Benefit Analysis into four steps or stages.

3.1.2 Four stages of CBA

The basic cost benefit analyses is divided into four stages or steps.

1. Identify and list all the relevant social costs and benefits connected with the projects.

2. Collect the data necessary to quantify the relevant costs and benefits.

3. Evaluate (in money terms) the costs and benefits, identified by the analysis.

4. Submit the finished CBA report and results, to the policy makers. (Turner & O'riordan).

Apart from these rules, the economic efficiency criterion is also to be satisfied. "Economic efficiency is said to increase when a reallocation of resources, for example building a new dam or air-port stimulates an increase in the net value of social output and its associated social consumption." (Y.J. Ahmad). These social output and consumption are interpreted by them to mean the production and consumption of both economic goods and services, along with all the non marketed environmental goods and services.

The basic CBA rule is that a project should be undertaken only if its social efficiency benefits exceeds the benefits of not undertaking the project. Now the benefits of not undertaking the project are in fact the social efficiency costs of the projects (known as opportunity cost). For if the project is undertaken these alternative social benefits have to be foregone. Thus the rule becomes, undertake the project if its net social benefits (total benefits - total costs) are positive.

3.2.1 Categories of CBA.

To start with, there are given few categories of CBA.

1. Environmental effect, may have the impact on human health. Positive or negative effects on health constitutes benefit and cost effect. Estimating them in money terms will be the further step.

2. Impacts on materials: Deterioration in environmental quality may lead to corrosion and destruction of materials. Higher cost of maintenance and protection is necessary. Monetary estimates are possible here.

3. Impact on natural resources : Changes in environmental quality may have an impact on the quality and availability of natural resources. Pollution of water (river, lake, sea), affects both the quality and availability of other natural resources. Extensive timber cutting may lead to erosion of the soil, which may increase the cost of agriculture production. (S. Lundgren).

Even if we have a good picture of the environmental effects associated with a project, it can be difficult to identify the various types of costs, benefits to associated with them. It can also be difficult to obtain quantitative physical estimates of those costs we can identify.

But when it is possible, we can proceed with CBA. Even though precise quantification is impossible, it may be feasible to get lower and upper bounds on the physical effects. Then we can proceed with CBA.

Thus the application of CBA to environmental policy is likely to encounter many difficulties.

1. Because of limited knowledge, we generally have to confine cost and benefits calculations to a subset of all relevant environmental consequences.

2. It is difficult to obtain full monetary measure of all those environmental impacts which have been identified. In the cases where the monetary estimation is possible, they are useful to decision makers. If we can not obtain full monetary measures, particularly monetary estimates may still be useful. It is possible to arrive at lower boundaries of the environmental costs involved in a project. Sometimes this is sufficient. If the lower bound is high enough to outweigh the benefits it is clear that the project should be rejected.

3.3 Impact of environment in planning of CBA and Measurement problems.

Lee explains CBA as a way to incorporate environmental considerations in the planning of the project. He expressed CBA in purely economic terms. The costs of a particular development project have included materials, labor, interest on borrowed capital and other easily quantifiable items. Benefits typically have included the stream of revenues generated by the project. It is cleared by him, that this type of analyses has limited scope for the projects of the society as a whole. What he wants to say is that the environmental impacts of that particular project must be taken in to accounts. The methodologies and criteria of evaluating projects with environmental expenditure should be greater than those, that flow from the best alternative use of resource involved.

The author illustrates the difficulties in measuring the costs of environmental change. Public goods do not have measurable market values, for example a change in the level of air pollution can not be computed. Therefore it is difficult to make actual costing of these projects.

Another measurement problem, is the valuation of inter-generational costs and benefits. Because of its short time horizon and its discounting future benefits to net present value CBA inherently undervalues or ignores many environmental functions and services. It discounts completely all future benefits.

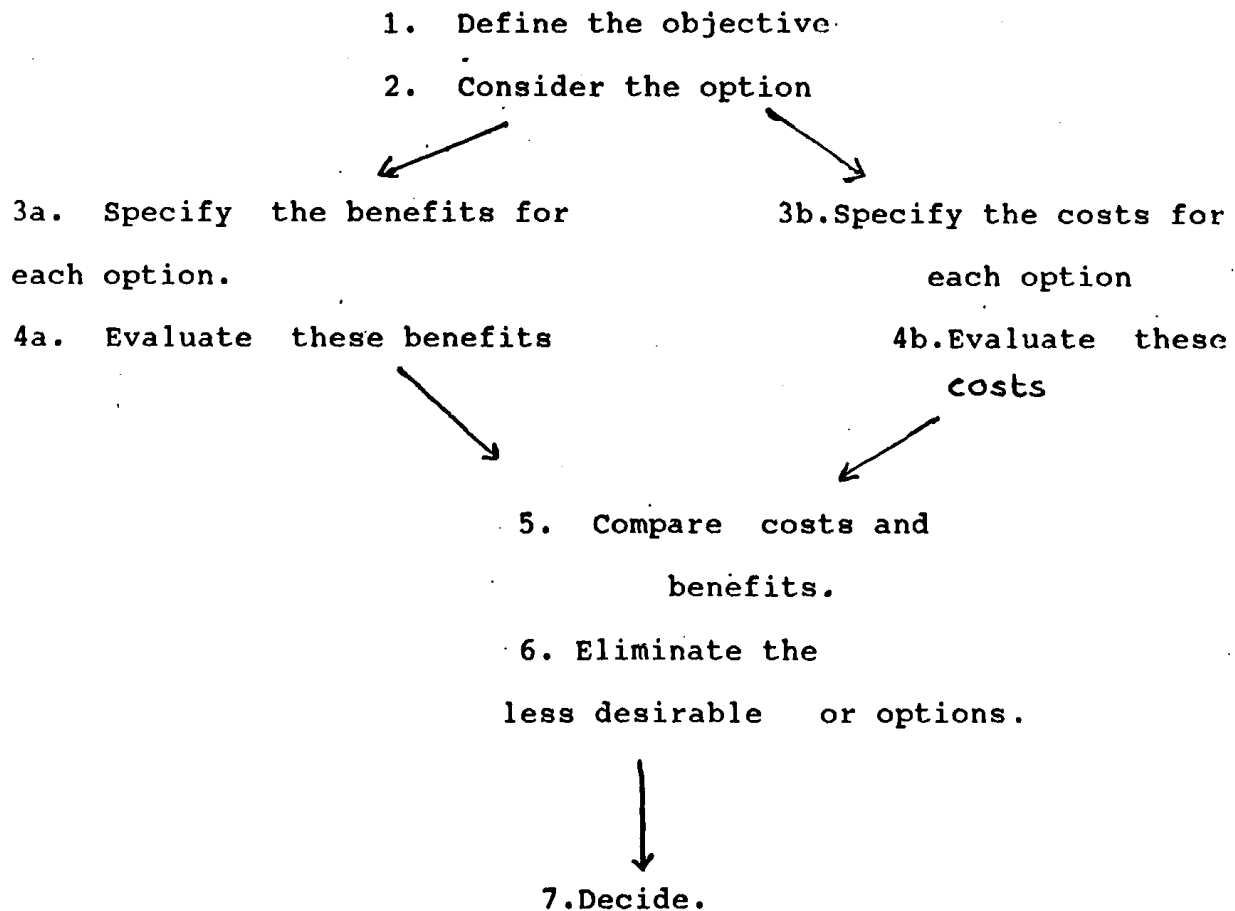
A final measurement problem, associated with CBA is its inability to evaluate properly the costs of irreversible damages to the environment, and foreclosing future options. Many complex natural habitats (Tropical rain forests and coral reefs) and their ecological services are now thought to be basically non renewable at least within the life span of human civilisation. It is therefore impossible to estimate the value of maintaining representative samples of these systems to preserve the scientific and economic options they guard for the future.

The environment is an important supplier of resources. Unfortunately for a number of reasons, they may not be mined by the society in a way that does not occur with most other resources. For these types of resources, there do not exist any competitive market. Therefore it is difficult to compute the cost of them. One natural resource may perform many functions which can not be priced. The decision maker would simply

dictate that the plant cease to pollute or stop production. Unfortunately either of these courses of action implies costs to the society. The conclusion is, it is very difficult to determine the optimal level of environmental damage. (M.A.Thomas).

There is a process, apart from all these difficulties in measurements, to analyze cost and benefits. The process of CBA has been illustrated as follows.

3.4 THE PROCESS OF CBA.



When the decision is taken there are two types of effects, Environmental and Non-environmental. Among these two, non environmental effects are straight forward to calculate in money terms, but it is difficult to calculate environmental effects. It entirely depends on the nature of the project.

3.5. Calculation of Costs and Benefits

For calculation of costs and benefits, benefits should be classified into two parts. (1) Benefits affecting marketed goods and (2) Benefits affecting non marketed goods. The first one is easy to calculate because a price is associated with it. It is again very difficult to calculate the benefits affecting non-marketed goods. We can not price clean air, clean water. So we have to give some shadow price to it. A choice has to be made and any choice will have a minimum or maximum price. For example, Suppose the choice is to spend X to secure Y units of pollution reduction. Should the decision maker consider this worthwhile it implies that he considers that $Y \cdot P > X$ (where P is a shadow price of pollution). That is $P > X/Y$. Then it should be decided that the expenditure is not worthwhile.

For comparison of cost and benefits he has given a technical appendix for the project of three years. (M. Thomas).

Benefits in Year 0 = B_0 , Costs in Year 0 = C_0

Benefits in Year 1 = B_1 , Costs in Year 1 = C_1

Benefits in Year 2 = B_2 , Costs in year 2 = C_2

Then Net Present Value,

$$= B_0 + \frac{B_1}{(1+r)} + \frac{B_2}{(1+r)^2} - C_0 - \frac{C_1}{(1+r)} - \frac{C_2}{(1+r)^2}$$

Where r = Social rate of discount

B_i

----- = Present or discounted value of benefits in year "i"
 $(1+r)^i$

That is, NPV = $\frac{\sum_{i=0}^n B_i - C_i}{(1+r)^i}$

For the project of "n" years,

$$NPV = \sum_{i=0}^n \frac{B_i - C_i}{(1+r)^i}$$

The Benefits Cost ratio is given by,

$$\frac{B_0 + \frac{B_1}{(1+r)} + \frac{B_2}{(1+r)^2}}{C_0 + \frac{C_1}{(1+r)} + \frac{C_2}{(1+r)^2}}$$

or, $\frac{\sum_{i=0}^n \frac{B_i}{(1+r)^i}}{\sum_{i=0}^n \frac{C_i}{(1+r)^i}}$

The ERR is given by "e",

$$B_1 - C_1 \quad B_2 - C_2$$

Where $B_0 - C_0 \frac{1}{(1+e)} + \frac{B_2 - C_2}{(1+e)^2} = 0$

Thus NPV is the more reliable guide to project selection. But there are some problems in application in CBA. But there are some problems in actual application of CBA.

3.6 The problems in application of CBA.

Following problems may affect any decision making aid.

1. Collected data may be inadequate.
2. Assorted valuation problems in certain circumstances valuation is impossible. For example it is difficult to determine the life estimation.
3. Willingness to pay varies with the life of the project.
4. Avoidance of double counting
5. Risks and uncertainty

CBA is a tool which measures the economic feasibility of a project. The society is willing to pay for a certain environmental quality which can be determined by the analysis. (Y.J.Ahmad).

A.J.Yusuf, described his own policy of conducting CBA. According to him the first step will be to identify the scope of the activity or projects and determine the projects and determine the priorities of effects for this. Adequate data must be available.

Further he highlighted the distinction between cost-benefits and cost effectiveness. They are all means of effectively organising the available information, for example, CBA identifies and evaluates the impacts of pollution in monetary terms to determine whether abatement will confirm a

net benefit on society, cost effectiveness analyses evaluates the marginal cost of controlling pollution at a certain level and identifies areas, where the relaxation or tightening of a control would increase social benefits. This way cost is easier to quantify. The author referred to the five categories developed by the American society to estimate the costs. Those are all fairly arbitrary but they are not without empirical support.

3.6.1 Types of the necessary data for case studies.

An article written by Johan Tacht and Hans Opschoor, "The role of Benefit evaluation in Environmental quality management."

Here they had given the data necessary for the case studies of CBA of pollution control measures.

1. Cost data: (a) For pollution control we have to invest some amount, that investment expenditure is the cost data. (b) Operating costs of pollution control equipment should be expressed as annual expenditure on labour, material, energy, maintenance etc.

2. Discharge data: Discharged reduction achieved by the control measures should be specified in some physical unit per time, (ton/per year).

3. Effects of discharge reductions on ambient concentrations. They should be expressed in standard physical measurement of ambient concentrations of dissolved oxygen.

4. Effects of charges in ambient concentrations on receptions. That is man, flora, fauna etc.

5. Monetary measures of physical land amenity effects on receptors.

3.6.2 Limitations of CBA.

There are limitations of CBA, with respect to environmental program consequences. (OECD 1972).

"As normally practiced CBA is an application of Neo classical welfare economics. Using the appropriate shadow prices to say that benefits are in excess of costs is formally equivalent to saying that gainers can overcompensate losers. In selecting projects where net social benefits are positive or in selecting that scale of output that maximises net social benefits, CBA provides a mechanism for choosing policies on the basis of a potential Pareto improvement." (OECD 1972).

Looking at the welfare aspect of CBA, While selecting Projects, whether they have positive benefits or not, this CBA provides a mechanism for choosing policies on the basis of the potential Pareto improvement. (J. Krutilla).

It has not been suggested here that CBA has no part to play in the formulation of environmental policy but rather that the limited significance of the information it provides should be fully considered in making decisions to invest in such studies.

Thus the application of CBA to environmental policy is likely to encounter many difficulties. But we may be successful in obtaining monetary measures of parts of the

relevant costs and benefits. Monetary estimates of costs and benefits are useful because they provide additional information to the decision maker.

When the review of case studies have been done, it is obvious that the benefits of the projects were interpreted generally as the effects following from the specified investment and considered mainly, of the increased Monetary returns. In assessing the net benefits, operational costs that were directly associated with production were deducted from the revenues derived from agriculture/industrial products.

No human society can avoid pollution entirely, keeping warm and cooking food, as a very minimum, requires fires, agriculture involves some run off of materials. But, too much pollution can lead to disaster. Somewhere in between may lie a most tolerable level of effluent discharge, justified by the usefulness of the polluting activities and also justified by the costs that would be required to carry these on with less pollution. But the problem is how to determine the tolerable level of pollution for the society. There have to be some additional criteria to define a tolerable level of pollution. This tolerable level can be derived by comparing costs and benefits. But at the starting point of the projects benefits may be higher than costs and afterwards, costs may grow more rapidly than benefits. Therefore there is a need to study the calculation of marginal costs also.

The economists thus defines the most tolerable level of pollution as one at which,

1. The population will not be destroyed,
2. Total benefits are greater than Total costs,
3. No alternative method is available that would add loss in production costs than it would take away from pollution costs,
4. The level of activity for the method chosen is such that Marginal costs and marginal benefits are equal.

3.7 Calculation of Marginal Costs

The review of the projects and activities done here are about the maintenance nessecited through flooding/ erosion and siltation. Here a distinction was made between social and economic costs and benefits. In practice it was not possible to measure all damage costs as a function of pollution level using co-relation methods and aggregating over the whole country or region. We can simplify the method by categorising areas as clean or polluted, by using the equation, (Y.J.Ahmad),

$$E = nc/ec + np/ep$$

Where E= Total national expenditure on the item under study.

"ep" is the unit expenditure in polluted area.

"ec" is the unit expenditure in the clean area.

"np" is the number of units in polluted areas.

"nc" is the number of units in the clean areas.

It is assumed that "ep" exceeds "ec" and that the difference was due to solely pollution. Then the marginal cost of pollution is given by,

$$\begin{aligned} C &= (nc/ec + np/ep) - (nc/ec + np/ec), \\ &= np(ep - ec) \end{aligned}$$

Thus if np, ep and ec are known "C" can be derived.

But so often ep and ec are often unknown. Let $ep = Fec$.

Then,

$$ec = \frac{E}{nc+npF}$$

and $C = np/ec (F-1)$

Where $F-1$

$$C = E \frac{F-1}{F+nc/n}$$

It is to be noted that the calculated costs are marginal costs.

The cost of controlling pollution will be large to the nation. They will come in the form of higher prices, higher local taxes, dislocation of existing plants and alteration in life times and habits.

There are three basic facts, about the economics of pollution.

1. The cost of reducing any type of pollution increases more than in proportion with the amount of pollution removed. In other words pollution removal at high levels is subject to increasing marginal costs.

2. The costs of pollution control differ very substantially from industry to industry and from firm to firm.

3. For almost every type of air and water pollutant there exist a large number of alternative control measures. There is a sharp difference between the alternatives.

It is an universal phenomenon, that greater the percentages of pollutants removed from an industrial process the higher will be the cost of removing an additional amount. When 30% of the BOD (biochemical oxygen demand) has been removed, the cost of additional removal of an additional pound is 6 cents, but once 90% of BOD is removed another pound costs 60 cents, above 95% the cost rises to 90 cents.

Another example of pollution removal cost for a hypothetical firm helps to make the point more clear.

% of BOD removed	Cost of removing an additional pound of BOD (cents).
40	2
60	4
80	7
90	10
95	15
99	40

(Yusuf J. Ahamad, Evaluating the environment, page 88)

These costs are not simply numbers for accountants or economists to ponder. They represent the value of the resources that must be channalised into controlling pollution and These resources will no longer be available for meeting the other wants of society. In the long run, their principle sources will not be the profits of industrial firms, but the higher prices and higher taxes that all of us will have to pay. Environmental goals therefore are not the simple consequence of decision

about how clean we want the air and water to be or how tough the Government should be with particular industries. Establishing them confronts us especially at the highest levels of control with a set of hard choices between environmental quality and other aspects of living standards in which the more we want of one we can have the less of the other.

These costs differ from industry to industry and firm to firm. Even within the same industry, firms may face quite different costs of removing pollution. The conclusion is that, the degree of pollution removal that each firm is required to make should take its costs into account.

Let us focus on the preventive side of the cost.

If the costs of pollution control increase to \$50 billion or \$60 billion per annum, they will absorb about 10% of the growth in per capita national income which could otherwise be used to and improve conditions in other ways. On the one hand this is large cost, on the other these huge numbers should not scare the nation, to halting economic growth. Even if we calculate the total cost of the project to make the things better, that would absorb, less than one quarter of the growth in per capita national income. The rest would still be available for other purposes. But the conclusion is that the costs of pollution control do not show up in the federal budget. They never appear on any single accounting record. But to be aware of costs is not to be in favor of status-quo. More awareness of

costs in framing the legislation of recent years might have given the nation more effective as well as less costly control policies.

The fact that CBA attempts to put a market value on costs and benefits is criticised, because market values reflect social and economic arrangements. The use of CBA tends to reinforce these social and economic arrangements, one of the ways to avoid the pitfalls of CBA is environmental Impact Assessment. (EIA).

EIA covers three concepts, Environment, Impact and analysis. These need to be defined in operational terms. Environment is a resource bundle. In practice, it has to be confined to an identifiable manageable system and it's bundle of resources.

3.8 Environmental impact assessment

Here is introduction of a new technique of Environmental Impact Assessment, (EIA). It can be added to CBA as an aid to project assessment. It is specially designed to look at both the nature and distribution of impacts that might result from a proposed action or program or policy initiative. Thus EIA deals with those effects that are not readily convertible in money terms and hence can not be inserted on the sheet of CBA. EIA also looks at the effects that can not be treated by the same discounting rates as most conventional economic costs and benefits as much in the future as at present since new wealth generated by present investment should be available for new schemes. Thus EIA can not always use the kind of discount rates

that are common in most CBA; indeed, it tries to avoid the practice of discounting altogether. Though this is preferable to environmentalist, it does create many problems for analyst, because he is bereft of any yardsticks to help him compare and hence weigh up different environmental effects.

3.8.1 Comparison between CBA and EIA.

Lundgren stressed that, "we have to take the list of the claims on the natural environment, which the project entails, while calculation of CBA. Afterwards we have to determine the the environmental effects of these claims. Then the step comes to the determination of the type of CBA associated with them. This step is also the start of the process of CBA.

Here he wants to address that the CBA can only be as thorough as the environmental impact assessment allows it to be. He proves it with an example. Suppose it is known that the project will (be) probably lead to a deterioration in water quality, but it may not be possible to tell exactly to what extent. It will also be unfeasible to determine the costs associated with it. The people responsible for the EIA generally have some idea of its thoroughness. What cost benefit analyses can do with regard to estimated environmental effects is to provide additional relevant information concerning the types of costs and benefits associated with them.

3.9 Evaluation of Environmental Costs

by optimising techniques.

Alan V.Knees gives an illustration of the use of optimization techniques in dealing with the environmental costs. The environment is defined as a system comprising the earth's living things and the thin global layer of air, water and soil, which is their habitat. The ecosphere is the joint product of all these things. If this system is destroyed it could never be reconstituted or replaced naturally or with human efforts. Ecosphere is the ecological cycle in which separate elements influence the behavior of the rest of the cycle and is in turn influenced by it. This cyclical process accomplishes the self purification of the environmental system. Waste products in one step becomes the necessary raw materials for the next. Such cycles are actually self governed. If they are disturbed by an external agency, then there is a fear of collapsing the cycle.

Human beings are dependent on the ecosphere not only for their biological requirements but also for resources which are essential to all their productive activities on purely theoretical grounds, any economic systems, which is growing by the rate at which it is used to growing from the ecosystem is must eventually drive the ecosystem to a state of the collapse. If the growth of the economic system is dependent on the productive activities, which are especially destructive of the stability of the ecosystem, then the above stated limit will come sooner.

3.9.1 Analysis of environmental problem

Now the environmental problems can be analysed. Suppose there are "n" business firms located around the lake which provides both water supply and residual absorption services. the discharge of waste reduces the utility of the lake for water supply.

Thus the terminology will be,

" y_i " = Industrial firms ($i=1$ to n) manufactures y_i units of products sold.

" P_i " = price of the product in competitive market.

" X_i " = units of inputs used by firms.

" w " = wages (labour is an input)

" Z_i " = waste material- firms put in the lake.

" q " = quality of the water.

(Each firm produces the same type of waste)

Quality of the lake water depends on the amount of waste discharge of each of the "n" firms and certain natural attributes of the lake (L). These natural attributes are not affected by waste discharges.

Objective : to maximise the difference between the value of output $P_i Y_i$ and the sum of the cost X inputs $W X_i$ and the cost of securing desired lake characteristics L, for the "n" firms subject to constraints resulting from the interrelationships among water supply and waste disposal.

Using standard Lagrangian multiplier analysis,

$$\max U = P_i Y_i - W X_i - c(L) - \lambda (q - Q(Z_1, \dots, Z_n, L))$$

This says the quality of water available for input depends on waste discharges to the lake and lake assimilative capacity.

Now the expression is differentiated, with respect to, X , Z , and q the following first order conditions are obtained for the maximisation problem.

$$\frac{u}{X_i} = P_i Y^i_{X_i} - W = 0, \text{-----1.}$$

$$\frac{u}{Z_i} = P_i Y^i_{Z_i} + Q Z_i = 0 \text{-----2.}$$

$$\frac{u}{q} = P_j Y^j_q - \lambda = 0 \text{-----3.}$$

$$\frac{u}{L} = Q_L - C' = 0 \text{-----4.}$$

Equation (4) says the marginal value of the unit change in the lake characteristics, L is to be equated to the marginal cost of L .

If (i) is substituted into "h" the result is,

$$\sum_{i=1}^n P_i Y^i_{X_i} + Q Z_i - \sum_{j=1}^n P_j Y^j_q = 0$$

The i^{th} private firm acting in its own interest will ignore the effect on productivity of all firms via water quality "q" resulting from an increase in its Z_i . Even the effect on Y^+q of an increase in Z_i is negligible in comparison with Y^+z if there are enough discharges.

Thus to attain the socially optimum " Z_i "s, a tax should be imposed on each unit of Z_i . The " Z_i "s and the " X_i "s will be reduced. That is the partial derivatives of the Y_i differ according to whether these taxes are imposed or not.

Some possible users of the lake might themselves be subject to congestion, for example recreational users. Therefore would have to be priced by the authority.

Further the model is extended, assuming that the industries or firms are located around the stream rather than a lake.

The model suggests the need for a basin wide authority, which will,

1. Levy a charge on waste discharge,
2. Explore the production function and implement resource improving investments where efficient.
3. Control land use.

Thus we have seen, that man uses the materials of nature in various ways. He eats, drinks them, burns them, extracts metals and chemicals compounds from them, and combines them into manufactured goods. He consumes the services or utilities that physical objects yield, but not the objects themselves. Materials

come from nature, are used and are returned to the earth in different form. The return of these residuals to nature can damage the environment.

This is what, the man is used to do through ages. But now the time has come to be aware of that. The problems of depletion of natural resources and various types of pollution are growing exponentially. This is because fast mechanisation of each and every thing. That is the western developed countries face the problem severally than developing countries.

It is not just sufficient to be aware of this problem, the programs should be taken to eliminate the effects of pollution. To eliminate the pollution and should go under the quantification level. Because for that, knowledge of just quality of environment will not be sufficient. The quantification is done at micro level with the help of cost and benefits approach. But it is not also sufficient to realise the problem at one project level, one should go beyond micro level and think over the economy as a whole, that is, macro level. The economy should know that how much and how fast the natural resources are depleted and in what form they are returning to the economy. What are the effects of that residuals the society is going to suffer (on health...etc.)

At macro level very little material is available. Input Output Approach is developed by W. Leontief, who tries to quantify the pollution and also tries to price it. So further the quantification at macro level will be developed.

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CHAPTER 4

DIFFERENT MODELS OF MEASUREMENTS OF POLLUTION

PART I

4.1 INTRODUCTION

Notion of pollution, has been introduced ages back by an eminent economist, Pigou. Nowadays everybody knows the pollution causes and effects of it. But the quantification of damages is not evaluated yet. Very little is known about it. Here an attempt has been made to the damages done by pollution to society and reduction in national income.

The problems of calculations of pollution has been studied at micro levels in the first two chapters. It has also been seen that there are different levels of pollution. Different sectors produce different levels or different quantities of pollution. But the repercussions of them are not limited only for the given sector. It is clear that industrial emissions and effluents can affect air and water, agriculture sector can harm man life, and pollution from these two sectors can affect the entire economy. It is very difficult to measure pollution effect quantitatively. But some models are developed to tackle the problem.

The models introduced by W. Leontief in (1970), Victor (1972), Cumberland (1966), Robert Ayers and Allen Kneese (1969), proposed some formal approaches. The technique used mainly is input output analysis.

What input output analyses does is to relate each industry's outputs and also to relate outputs to final demands by consumers. With this the effects of changes in individual industries on each of the other industries can be assessed. Some of the changes in the final demand also can be assessed in each industry. The technique is quite general, it is possible to introduce for example an industrial sector devoted to anti pollutional measures and to assess the effects of such measures on the industrial structure. If the prices are put into the model, the effects of such measures on the structure of prices also be estimated and so on.

Similarly if we know the relationship between output and wastes, the effects of changes in final demand on waste generation can also be estimated and further extensions might allow us to estimate the effects of various changes in resource demand. These analysis can become very complicated.

4.2 Different models of measurement of pollution.

The input output approach is designed to be implemented empirically and applications have been made to environmental problems whether input output (I-O) models will be successfully applied to environmental problems depends first on whether the very detailed information they require will be available and second on whether the well known defects of I-O analysis are thought to render their results too untrustworthy. (Pearce).

Let us have a brief overlook of the general Leontief I-O models.

Input Output analysis for an entire economy is based on an accounting of the flow of goods and services in dollar terms at a particular time. Part of this flow is an inter industry flow. transferred from an industry to be used in production process in remainder flows to an exogenously defined final demand sector. This sector generally includes households, Governments and Foreign Trade.

For an "n" sectors economy the inter industry input coefficients are arranged as a matrix $A = [a_{ij}]$

Table 4.1

	Input from industry	Output From Industry			
		1	2	3	----- n
1	a_{11}	a_{12}	a_{13}	a_{1n}	
2	a_{21}	a_{22}	a_{23}	--- a_{2n}	
3	a_{31}	a_{32}	a_{33}	a_{3n}	
n	a_{n1}	a_{n2}	a_{n3}	---- a_{nn}	

The first column of this matrix says that to produce a dollar worth of commodity 1. Inputs of a_{11} units of commodity 1. a_{21} units of commodity 2 etc. are needed. Frequently the matrix is set up in such away that no industry uses its own output. In that case the elements, those from the upper left hand to the lower right hand corner are zero.

If industry 1 is to produce an output just sufficient to meet the input of the "n" industries as well as final demand of the open sector, its total output designated x_1 must satisfy the following equation.

$$X_1 = a_{11}x_1 + a_{12}x_2 + \dots + a_{1n}x_n + d_1$$

It can be rewritten,

$$(1 - a_{11})x_1 - a_{12}x_2 - \dots - a_{1n}x_n = d_1$$

If we rewrite the equations for industry 2,3, ...,n, then we will get the same results, as above, but diagonal components are deducted from one. This matrix is similar to matrix (I-A) because when matrix "A" is deducted from "I" matrix (identity matrix), then we will get the results similar to the above one.

Thus we can write $(I-A)x = d$,

Where I = n x n identity matrix

A = n x n Coefficient matrix

and x,d are both n x 1 vectors. "x" is the variable vector and "d" is final demand vector. If (I-A) has the rank n its inverse can be found and the system of "n" simultaneous equations represented by the above matrix equation will have the solution.

$$x = (I-A)^{-1}d$$

Providing solutions for "n" simultaneous equations representing commodity and services flows from industries to industries and to final demand, the inverse matrix $(I-A)^{-1}$ has great importance. Once it is available "d" can be multiplied by

this inverse and a new solution vector produced for the industry output "x" always on the assumption that the coefficients of the A matrix have not changed.

Leontief (1970) proposed an extension of the basic open I-O model, which would permit forecasting of residual emissions and at least gross effects of certain types of policy measures with respect to them. Pollution produced directly by households and other final users is not considered in it. Pollution and other external effects of production or consumption activities should for all practical purposes be considered part of the economic system. He has extended I-O table to include a pollution abatement sector. This is an important departure since pollution abatement is itself an industry requiring inputs from other industries. Also pollution coefficients are estimated, related tons of pollutant to same unit of value of industrial output.

In this "n" sector economy, we will now add pollution row and column. Pollution column gives us the cost of pollution elimination sector wise. Pollution row gives us the input for pollutants sector wise.

Now let us start from coefficient matrix. Assume that there are first "n" sectors in the economy and now we are adding (n+1) sector; pollution sector to it.

Table 4.2

Input	Output From Industry				
	1	2	3	----- n	n+1
1	a_{11}	a_{12}	a_{13}	a_{1n}	$a_{1,n+1}$
2	a_{21}	a_{22}	a_{23}	a_{2n}	$a_{2,n+1}$
3	a_{31}	a_{32}	a_{33}	a_{3n}	$a_{3,n+1}$
...					
n	a_{n1}	a_{n2}	a_{n3}	a_{nn}	$a_{n,n+1}$
n+1	$a_{n+1,1}$	$a_{n+1,2}$	$a_{n+1,3}$	$a_{n+1,n}$	$a_{n+1,n+1}$

The above matrix is coefficient matrix. Now to get the production level of each sector we can prepare transaction matrix.

Table 4.3

Transaction Matrix.

Input	Output From Industry				
	1	2	3	----- n	n+1
1	$a_{11}X_1$	$a_{12}X_2$	$a_{13}X_3$	$a_{1n}X_n$	$a_{1,n+1}X_{n+1}$
2	$a_{21}X_1$	$a_{22}X_2$	$a_{23}X_3$	$a_{2n}X_n$	$a_{2,n+1}X_{n+1}$
3	$a_{31}X_1$	$a_{32}X_2$	$a_{33}X_3$	$a_{3n}X_n$	$a_{3,n+1}X_{n+1}$
...					
n	$a_{n1}X_1$	$a_{n2}X_2$	$a_{n3}X_3$	$a_{nn}X_n$	$a_{n,n+1}X_{n+1}$
n+1	$a_{n+1,1}X_1$	$a_{n+1,2}X_2$	$a_{n+1,3}X_3$	$a_{n+1,n}X_n$	$a_{n+1,n+1}X_{n+1}$

While coefficient $a_{1,n+1}$ denotes that to eliminate 1 gram of pollution $a_{1,n+1}$, should be the output of agriculture sector. The term $a_{1,n+1}X_{n+1}$ explains here that, the total output of agriculture sector which goes to pollution elimination sector as an input to eliminate pollution.

On the other hand $a_{n+1,1}X_1$, denotes that the level of total output of pollutants produced by the first sector. While coefficient $a_{n+1,1}$, denotes that " $a_{n+1,1}$ " is the amount of pollutant which is produced by the one unit production of first sector. Therefore, $a_{n+1,n+1}X_{n+1}$ means, whatever is produced pollution, is eliminated, therefore that is equal to zero.

4.3 Impact of pollution on National Income.

For calculation of national income, we have to add value added. Total output of a sector minus inputs required, for that sector, can give us the value added of that sector. Adding all value added from each sector we can get the level of national income.

Therefore,

$$X_1 - \sum_{i=1}^n a_{1i}X_i = \text{value added by first sector,}$$

$$X_2 - \sum_{i=1}^n a_{2i}X_i = \text{value added by second sector,}$$

$$X_3 - \sum_{i=1}^n a_{3i}X_i = \text{value added by third sector,}$$

$$X_n - \sum_{i=1}^n a_{ni}X_i = \text{value added by } n^{\text{th}} \text{ sector,}$$

Therefore, when pollution sector is not introduced, the national income of the economy will be,

$$\sum_{j=1}^n (X_j - \sum_{i=1}^n a_{ij} X_j)$$

Now it is decided to introduced pollution sector. That is pollution elimination as column and pollution as row. if we already have the addition of inputs up to "nth" sector and also assume that pollution production goes to pollution elimination sector that is $a_{n+1, n+1} X_{n+1} = 0$, then we will just add up all the elements of n+1th sectors, row wise and subtract it from national income. Then we will get the real (reduced level of) national income. That is,

$\sum_{j=1}^n (X_j - \sum_{i=1}^n a_{ij} X_j) - \sum_{j=1}^n a_{n+1, j} X_j$ will be the reduced level of national income.

4.3.1 Empirical example of reduction in National income.

Now let us take a numerical example to illustrate the above. Consider the three sectors economy.

1. Agriculture, 2. Industry, 3. Others.

The figures of the Indian Economy for the year 1983-84 are used for our illustration. The pollution coefficients for the row and column are informed guesses.

(Values are given in Rs. in Chores)

Table 4.4

	Agri.	Industry	Others	F.D.
Agri.	16792	23468	2550	57913
Industry	8081	51608	13595	74170
Others	4202	21658	13901	66339
V.A.	72552	44548	68715	185815
Totals	100852	152207	101240	35429

We can see here that the original national income will be Rs. 185815 crs. Now let us add pollution input row and pollution elimination column ^{How?}

Table 4.5

	Agri.	Industry	Others	Pollution	F.D.
Agri.	16792	23468	2550	5329.07	57913
Industry	8081	51608	13595	7105.43	74170
Others	4202	21658	13901	5329.07	66339
Pollution	2004.4	12592.2	3167	0.0	
V.A.	70547.6	31955.9	65548	----	----- -

Reduced level of National income = 168051.43

 Net addition of V.A. we will get the reduced national income. At first it was Rs.185815 crs. Now it is 168051.43.

4.4 On the extension of I-O analysis, to account for Environmental externalities.

Robert Ayeres and Allen V.Knees, have extended I-O analysis, to include the flow of wastes to the environment and the recycle flow of wastes to the production sector. This was done by adding two sectors, consumption and environment. All output from the consumption sector is either recycled or sent to environmental sector.

In addition to this material, the environmental sector also receives flows directly from the various production sectors.

In this Ayres and Knees model, the flow of water from the K^{th} production sector to the environment is given by $C_{k0}X_0$, where C_{k0} = the fraction that comes from the K^{th} sector and X_0 is the total mass of residuals discharged to the environment.

(X_0 = numerically to the total amount of raw materials withdrawn from environment, inventories being neglected.)

Assume that the output of non waste commodity from j^{th} sector increases, therefore, there will be increase in raw materials required and hence an increase in X_0 , that is $*$. The increase in the flow of wastes from the K^{th} sector would be $C_{k0}*$. Whether the production of this sector were changed or not.

Further more the increase from the j^{th} sector would be $C_{j0}*$ rather than proportional due to the change in the amount of the j^{th} commodity.

P.T.O.

In the usual commodity production sectors of the Leontief I-O analysis, the inputs are set by the output of that sector.

However in the case of waste inputs to the environmental sector, the inputs are set by the outputs of other sectors. This fundamental relationship is absent from the Ayeres and Knees formulation.

4.5 Victor's Model

These works only deal with materials and energy flows up to the point where these enter the environmental assimilator.

Since the I-O technique is quite general, it is possible to introduce an industrial sector devoted to antipollution measures on the industrial sector. If prices are put into the model, the effects of such measures on the structure of prices can also be estimated and so on.

Similarly if we know the relationship between output and wastes, the effects of changes in the final demand on waste generation can also be estimated and further extensions might allow us to estimate the effects of various changes on resources demand.

There are several types of I-O tables. Following Victor we can extend the idea to a more general framework. The following figure shows various matrices, vectors and some scalars. We are extending the I-O matrix including environment. Environment is introduced by way of an entry, "Environmental commodities" and "discharges to environment". Here according to Victor, the environment as a receiver of waste, has no observed market

value. Hence waste discharges and the withdrawn of environmental commodities are measured in physical term, and the measure used will be weight. (Pearce & Turner).

	Commo.	Ind.	E.D.	Total	Waste discharged to Environment.
Commo.		A	D	F	N
Ind.	B		G		O
Primary Inputs		C	E	H	
Totals	K	L	M	J	P
Enviro. Commo.	Q	R		S	

Matrix A= Industrial demand for commodities to be used as inputs.

Matrix B= The sales of each commodity by each industry.

Matrix C= The expenditure by each industry on each primary input.

Matrix D= Category of final demand, the demand for each commodity.

Matrix E= Relates final demand categories to expenditure on primary inputs.

Vector F= total demand (industrial+Final)

Vector G= Total outputs of each industry.

Vector H= Total expenditures on each primary input.

Scalar J=Total expenditure on all commodities and all primary inputs.

Vector K=Total outputs of commodities.

Vector L= Total inputs to industry.

Vector M=Total expenditure by category of final demand on all inputs.

The remaining six entries are from environmental sector.

Matrix N= The amount of waste discharged as a result of the final demand for commodities.

Matrix O= Shows the discharge of waste by industry.

Vector P= The total amount of waste discharged by category of waste.

Matrix Q= Inputs of environmental commodities to economic commodities. For example, how much water is used, how much land is used and so on.

Matrix R= Shows the inputs of environmental commodities to industries.

Matrix S= The total input of environmental commodities to industrial and final demand.

How far one can quantify the inter industry linkages in details is not our concern here. The basic aim has been to show that economy and environment are linked in various ways and that at least, it is possible to model these linkages by extending a piece of analysis. Input Output model, that was initially developed for purposes quite unrelated to the environment. It also permits us to reflect on just what the environment does for economy.

4.5.1 Leontief's Model incorporating
more than one sector for pollution

Pearce has drawn a figure Leontief's input output model.

Matrix A: is the traditional I-O matrix, relating inputs to outputs consisting of elements a_{ij}

Matrix B relates industrial inputs to pollution elimination activities, which as we noted, is a co-ordinal feature of Leontief's system.

	Industry 0	Antipollution activities
Industry inputs	A	B
Pollution Outputs	C	D

(Source :D.W.Pearce, Environmental Economics, Page 55)

Matrix C relates pollution emissions to industrial outputs, so that the components here are the pollution coefficients.

Matrix D relates antipollution activities to pollution, so that the elements will tell us how much pollution reduction occurs as a results of antipollution activity.

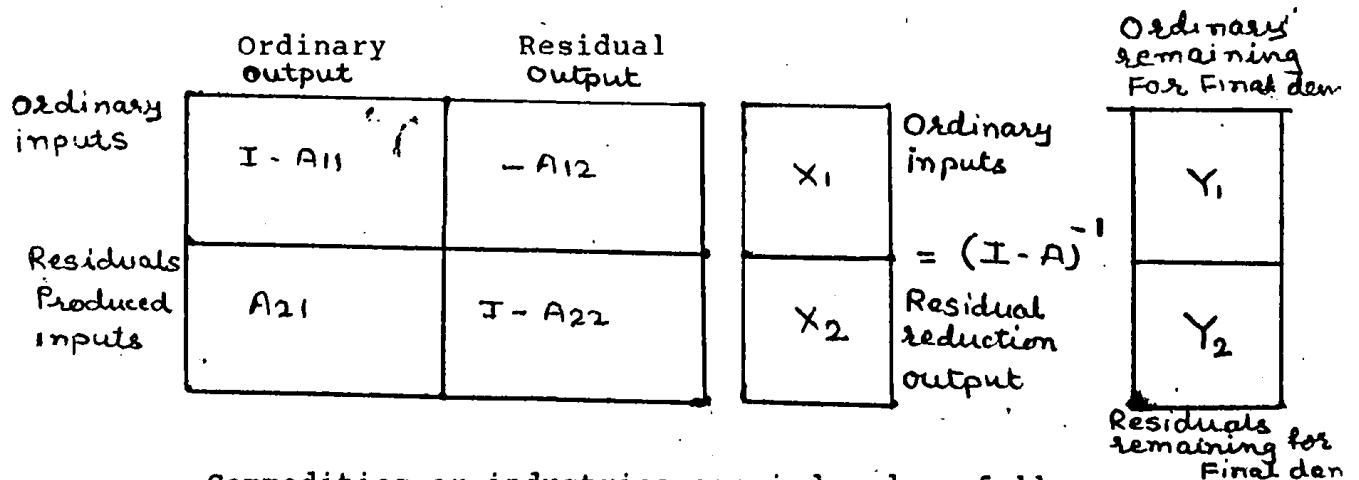
By manipulating the model, Leontief is able to assess the effect on the level of emissions in individual industries of particular levels of final demand. At the aggregate level, the model permits the estimation of the total level pollution, that will result if a given projected level of final demand occurs. The model can also estimate the price effects of particular antipollution measures.

4.6 Review of Leontief's model

by Allen V. Knees.

Allen V. Knees, in his book, "Economics and the environment" has reviewed the I-O extended matrix of Leontief. What he wants to say is, residuals are handled somewhat differently from ordinary commodities. He has drawn a figure, of it.

INPUT OUTPUT BALANCE.



Commodities or industries are indexed as follows,

(1, 2, -----, i, -----, j, -----, m) (m+1), -----, k, -----, 1, -----, n

Ordinary goods

Residuals

Input output balance with pollutants included in the system is shown above .

We have "m" ordinary goods and n-m pollutants, making a total of n inputs and outputs.

Each of the "a" matrices is a matrix of I-O coefficients, for example, a_{ij} is the amount of the "ith" ordinary input required per unit of the "jth" ordinary output (sub matrix of A11)

a_{ik} is the amount of the ith ordinary input required to produce a unit of the kth residual reduction output (sub matrix of A12)

a_{ji} is the amount of the jth residual resulting from producing a unit of the ith ordinary output (sub matrix of A21)

a_{ki} is the amount of the kth residual produced as a result of a unit reduction in the ith residual (sub matrix A22)

Next he wants to see what is involved in this system. he has separated each of them. For that he assumed, three ordinary commodities and two pollution reduction activities. Total 5 outputs or inputs. For example,

$$[1 \quad -a_{12} \quad -a_{13} \quad -a_{14} \quad -a_{15}] \begin{vmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \end{vmatrix} = Y_1$$

or $x^1 - a^{12}x^2 - a^{13}x^3 - a^{14}x^4 - a^{15}x^5 = Y_1$

This equation simply says that output of the first commodity minus the amount used in the production of X_2, X_3, X_4 and X_5 is equal to the amount of the first commodity Y_1 , going to the final demanders.

Similarly the last equation will be,

$$a^{51}x^1 + a^{52}x^2 + a^{53}x^3 + a^{54}x^4 - x^5$$

This says that the residual which is commodity' number "5" that is generated in the production of x_1, x_2, x_3, x_4 , minus the amount by which this residual is reduced equals the amount which goes to final demanders.

Thus the I-O balance is $A \times X = Y$ where X and Y are vectors of industry outputs and delivers of final goods, respectively. Industrial outputs includes residuals reductions and final goods includes residual received.

According to Leontief, within the frame work of the open I-O model, any reduction or increase in the output level of pollutants, can be traced. It can change the technical structure of one or more sectors of the economy.

4.7 Effect of pollution on prices.

Economists can anticipate the effect of output of pollutants on any given technology. With given value added coefficients they can estimate the effect of such a change on prices of various goods and services. After this Leontief had given a simple example and wanted to show, that how any of these questions can be formulated and answered in I-O terms.

He has considered the simple two sector economy. The original state and structure is already explained with taking numerical values. Now he is assuming that a process has been introduced, permitting elimination of pollution and that amount to 2 man years of labour.

Combined with the previously introduced sets of technical coefficients this additional information yields the complex structure of matrix.

Instead of describing complete elimination of all pollution, he introduced Y_3 as an uneliminated pollutant. It is not demanded but tolerated. With this we can see the effects of reduction in the amount of pollution delivered to the final users would have on the total output levels of all other industries. It is accepted here that economic activities do generate some grams of pollutants.

Next he wants to explain the price cost relationships within agriculture and manufacturing sectors. He states that the price of eliminating 1 gram of pollution (p_3) should be just high enough to cover the value added (V_3), that is the payments to labour and other primary factors employed directly by the antipollution industry. After calculations he gets the prices as $P_1 = \$2.00$, $P_2 = \$5.00$, $P_3 = \$3.00$. Thus the price (cost per unit) of eliminating pollution turns out to be \$ 3.00 per gram. The prices of agricultural and manufactured goods remains the same. That is to tolerate the cost of eliminating some part of the total pollution generated by system the household have to suffer. These payments could be made directly or they might be

collected in the form of taxes imposed on the households and used to the Government to cover the costs of privately or publicly operated antipollution industry.

The price system would be different if through voluntary or by law, each industry undertook to eliminate all or at least some fraction of the pollution at it's own expense. The added cost would of course, be included in price of it's marketable products.

After making relevant calculations we can see that the prices have changed. $P_1 = \$3.234$, $P_2 = \$5.923$, $P_3 = 3.185$.

The prices are now higher than they were before. From the point of view of households the final consumers the relation between real costs and real benefits remains the same, having paid for some antipollution activities indirectly, they will have to spend less on them directly.

4.8 Differences and critical examination of I-O models.

4.8.1 An assessment of I-O approach

1. It has not accounted in a logically complete manner for the residuals generated in the production and consumption, in the initial attempts at application that is some residuals may not be accounted for.

2. It is usually not correct to think of residuals control as taking place in a separate residual control sector or even in separate residual control activities. The residual output coefficients of I-O approach can change either from new application of existing technology or development of new technology.

3.The model focuses on residuals generation and discharge. it does not analyze what happens to residuals once they enter into the environment nor does it incorporate any considerable damages.

4.The model focuses on residuals control costs but gives no attention to the value of loss in function of common property resources when their quality deteriorates due to the effects of residuals discharges.

We observed here, in this chapter, that materials flow through the economy is to treat economic environment interaction in terms of extended I-O models. The basic principles of I-O could be extended in this way. It is true that not all i-O models extended, have observed the principles of material balance.

4.8.2 Differences between the models.

I-O models can be used to evaluate policies, if they are extended to contain some valuation procedure. We noted that one attempt in this direction that of Victor (1972), was rather weak, but there is possible scope for extending the basic idea of consensus expert valuation. Whether I-O models will be successfully applied to environmental problems depends first on whether the very detailed information available and second on whether the well known defects of I-O analysis are thought to render there results too untrustworthy.

References:

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CHAPTER 4

PART II

MEASUREMENT OF POLLUTION

Estimation of pollution and empirical work to measure
Gross output levels and National income.

4.9 Introduction

It has been seen, in the first part of this chapter, some models developed by some economists on the basis of I-O analysis. As we know, pollution is a by-product of regular economic activities, in each of its many forms it is related to in a measurable way to some particular consumption or production process. The quantity of carbon monoxide released in the air, bears a definite relationship to the amount of fuel burns by various types of automotive engines, or the discharge of polluted water into streams and lakes is linked directly to the level of output of steel, the paper, the textile and all the other water using industries, and its amount depends on the technological characteristics of the particular industry.

Input Output analysis describes and explains the level of output of each sector of a given national economy in terms of its relationship to the corresponding levels of activities in all other sectors. By the day to day operations of our economic systems these are many undesirable by-products are emitted. The technical interdependence between the levels of desirable outputs can be described in terms of structural coefficients.

It is the purpose of these models to explain how externalities can be incorporated into the conventional input output picture of the national economy, and second to demonstrate that once this has been done, then conventional I-O computations can yield concrete replies to some of the fundamental factual questions, which were asked before the practical solutions can be found to the problems raised by modern technology and uncontrolled growth.

It will be shown here, that to maintain the same level of national income and final demand, and also eliminate pollution; the level of gross output have to increase. If it is impossible for the economy to increase the levels of outputs then the final demand sector, that is, consumers will have to suffer, and national income will get reduced. To sustain the same level of final demand we have to increase output.

4.9.1 TO increase the level of output.

With the reference to our developed model in the first part of this chapter, (4,3), and the results what we have got by empirical work, (4.3.1), we conclude that as expected, the national income is reduced. but some how it sounds quite uneconomic, because for elimination of pollution there will be reduction in final demand, which is quite uneconomic. This is because we are assuming here the level of production could not increase, and in the same level of production, we have to add more demand from the pollution abatement sector. That naturally reduces the level of final demand. But as a feeling, that this possibility of reduction in final demand is impossible, we will now develop another model

which will increase the level of production for the pollution abatement sector. Now final demand sector will be intact, and each sector has to produce more to fulfill the demand for pollution abatement sector. Here we will get the result that gross national product is now increasing

To get the final output levels, we have to shift to the table 4.3, transaction matrix.

Transaction Matrix.

Input	Output From Industry				
	1	2	3	----- n	n+1
1	$a_{11}X_1$	$a_{12}X_2$	$a_{13}X_3$	$a_{1n}X_n$	$a_{1,n+1}X_{n+1}$
2	$a_{21}X_1$	$a_{22}X_2$	$a_{23}X_3$	$a_{2n}X_n$	$a_{2,n+1}X_{n+1}$
3	$a_{31}X_1$	$a_{23}X_2$	$a_{33}X_3$	$a_{3n}X_n$	$a_{3,n+1}X_{n+1}$
n	$a_{n1}X_1$	$a_{n2}X_2$	$a_{n3}X_3$	$a_{nn}X_n$	$a_{n,n+1}X_{n+1}$
n+1	$a_{n+1,1}X_1$	$a_{n+1,2}X_2$	$a_{n+1,3}X_3$	$a_{n+1,n}X_n$	$a_{n+1,n+1}X_{n+1}$

We will make the equations with addition of inter industry demand and final demand

The output of first industry will be the demand for other industries and final demand from consumers. So, the equation will be,

$$X_1 = a_{11}X_1 + a_{12}X_2 + \dots + a_{1n}X_n + a_{1,n+1}X_{n+1} + D_1$$

$$X_2 = a_{21}X_1 + a_{22}X_2 + \dots + a_{2n}X_n + a_{2,n+1}X_{n+1} + D_2$$

$$X_n = a_{n1}X_1 + a_{n2}X_2 + \dots + a_{nn}X_n + a_{n,n+1}X_{n+1} + D_n$$

$$X_{n+1} = a_{n+1,1}X_1 + a_{n+1,2}X_2 + \dots + a_{n+1,n}X_n + a_{n+1,n+1}X_{n+1} + D_{n+1}$$

So it can be rewritten as,

$$(1-a_{11})X_1 - a_{12}X_2 - \dots - a_{1n}X_n - a_{1,n+1}X_{n+1} = D_1, \text{ and so on.}$$

If we rewrite these equations for industries 1 to n and (n+1), then diagonal components will be deducted from one. But as suggested by Allen V. Knees, the residuals which is commodity no. (n+1), that is generated in the production of X_1 to X_n , minus the amount by which this residual is reduced, equals the amount which goes to the final demanders. Therefore, our last equations will be,

$$a_{n+1,1}X_1 + a_{n+1,2}X_2 + \dots + a_{n+1,n}X_n - X_{n+1} = D_{n+1}$$

Then in the matrix form it will be,

$$(I-A)X=D$$

Where I=identity matrix,

A=coefficient matrix,

X and D are vectors.

To get the level of X we will get $(I-A)^{-1} D$.

To relate this equation to pollution row and sector, it can be said that to sustain the same level of final demand and also to eliminate some pollution level, output of each sector or industry should increase. Up to what limit this level will increase that we have to see.

4.10 Introduction of neutralisation factor.

For this purpose, if some neutralisation factor " λ " is introduced. Two extreme limits can be put to it. 0 and 1. That is, λ lies between 0 and 1. $\lambda = 0$, means, there is no pollution neutralisation, and $\lambda = 1$, means there is 100% elimination of pollution. Now let us first compare between these two

extremes. That is, how much production level should increase when there is no pollution neutralisation, ($\lambda = 0$) and when there is 100% neutralisation, ($\lambda = 1$).

Then, some fixed value (< 1), can be given to λ , and the output levels can be observed. Two models can be developed for this, 1. Constant neutralisation model,

2. Variable neutralisation model.

4.10.1 Observation of two extremes.

It is assumed that there is no pollution elimination or abatement sector. That is there is no elimination of pollution. Then there will be no increase in output levels or no decrease in national income. National income will be ,

$$\sum_{j=1}^n (X_j - \sum_{i=1}^n a_{ij} X_j)$$

where $i=1$ to n

$j=1$ to n

When there is 100% elimination, it is assumed that, whatever is the production of pollutants all eliminated. In this case, the final demand for pollution is "0". because all pollution is eliminated, and there is no pollution imposed on consumers. It is obvious that any way, there will be no "DEMAND" for pollution, but whatever will be the remaining level, that will be considered as final demand for consumers. Thus in this model, it has to be seen, that if there is 100% elimination, then how much increase in production level. In this case, there will be no change in national income but we to increase the level of

output. So there will be certain variable losses. No increase in national income means, whatever increase in production will be there, all will be wiped out by inter industry demand.

Now it is assumed that the value of " λ " is 1.

By table 3.3, Transaction matrix, the equation, $(I-A)^{-1} D = X$, is derived.

When $\lambda = 1$, final demand for pollution is 0.

That is $D_{n+1} = 0$.

These equations can be rewritten in matrix form,

$$(I-A)^{-1} \begin{pmatrix} D_1 \\ D_2 \\ \vdots \\ D_n \\ 0 \end{pmatrix} = \begin{pmatrix} X_1 \\ X_2 \\ \vdots \\ X_n \\ X_{n+1} \end{pmatrix}$$

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4.10.2 Empirical examples of two extremes.

Let us take the same example, as before. (Table 4.4)

	Agri.	Industry	Others	F.D.
Agri.	16792	23468	2550	57913
Industry	8081	51608	13595	74170
Others	4202	21658	13901	66339
V.A.	72552	44548	68715	185815
Totals	100852	152207	101240	

National income = 185815. As there is no introduction of pollution sector, $\lambda = 0$. No neutralisation of pollution. Output levels are, for the agriculture sector = 100852, for industrial sector = 152207, for "other" = 101240.

Now let us add pollution row and column. (Table 4.5)

	Agri.	Industry	Others	Pollution	F.D.
Agri.	16792	23468	2550	5329.07	57913
Industry	8081	51608	13595	7105.43	74170
Others	4202	21658	13901	5329.07	66339
Pollution	2004.4	12592.2	3167	0.0	

For the second extreme that is $\lambda = 1, 100\%$ neutralisation, let us see how much is the output level. For that we have to take the coefficient matrix.

Coefficient matrix.

.1667	.1591	.0125	0 .3
.0802	.3499	.0669	0 .4
.0417	.1470	.0684	0 .3
.0199	.0854	.0156	0 .0

Now let us take (I-A).

.8333	-.1591	-.0125	-0.3
-.0802	.6501	-.0669	-0.4
-.0417	-.1470	.9316	-0.3
.0199	.0854	.0156	-1

Now let us take $(I-A)^{-1}$, Inversion is done with the help of computers.

1.253	0.391	0.054	-0.548
0.191	1.719	0.139	-0.787
0.100	0.340	1.107	-0.498
0.042	0.159	0.030	-1.085

$(I-A)^{-1} D = X$

So the final level of outputs, we have to multiply by final demands of each sector to the column of that respective sector.

72593.9	+ 29007	+ 3588.3	+ 0.00	=105190.72
11078.7	+ 12754.9	+ 9534.39	+ 0.00	=253054.83
5791.3	+ 25247.5	+73470.44	+ 0.00	=357564.04
2478	+ 11859.8	+ 2004.44	+ 0.00	= 16341.89

It is now easily observed that the output levels are increased, than what they were before.

$\lambda = 0$	$\lambda = 1$
100723	105190
144749	253054.83
203016	357564.04
0	16341.89

In other words, to eliminate 100% of pollution, the economy have to produce increased levels of output. To sustain the same level of final demand, gross level of output has to be greater than what was it before. but as we have seen that there is no 100% elimination of pollution, it is possible to control it partly.

4.11 Constant neutralisation factor model.

In this type of model, it is assumed that there is some fixed percentage of neutralisation, which is applied to all sectors. That is suppose Government has decided to recover 25% of pollution, then how much the production level will be affected, that will be seen in this type of model. Here $\lambda < 1$. Therefore, there is some level of pollution imposed on consumers. That is final demand. Thus now there exist some level of demand for pollution.

In the first extreme level models, final demand was "0". That is " D_{n+1} " = 0; now in this constant neutralisation model, final demand will be whatever is the remaining part of pollution that is

$$(1 - \lambda)X_{n+1} = D_{n+1}.$$

Therefore,

$$(I-A)^{-1} \begin{bmatrix} D_1 \\ D_2 \\ \vdots \\ D_n \\ D_{n+1} \end{bmatrix} = \begin{bmatrix} X_1 \\ X_2 \\ \vdots \\ X_n \\ X_{n+1} \end{bmatrix}$$

4.11.1 Empirical example of constant neutralisation model.

As we have introduced $\lambda < 1$, the neutralisation factor, let us assume that the economy could recover 25% of total pollution. Therefore, $\lambda = 0.25$. Thus now our final demand will be, $(1-\lambda) = 0.75$.

Total output of pollution is 17763.57

25% of it is recovered that is = 4440.89

Therefore, final demand is $17763 - 4440.89 = 13322.68$.

Now,

$$(I-A)^{-1} D = X$$

1.253	0.391	0.054	-0.548	57913
0.191	1.719	0.139	-0.787	74170
0.100	0.340	1.107	-0.498	66339
0.042	0.159	0.030	-1.085	13322.7

The results are,104444.85

242568.55

350922.68

1873.49

4.12 Variable neutralisation factor model.

Now let us develop the model with variable neutralisation factor " λ_i ". Where $\lambda_i < 1$.

λ_i is a variable factor which can be apply to any one sector. The value of λ_i , can be varied from sector to sector, this is because you can not apply one constant neutralisation factor to all sectors. The capacity of elimination of the pollution of each sector is different. Therefore, it is worth to apply this modified model of variable neutralisation factor.

Our main (4.3) transaction model is (with pollution sector), as follows.

Transaction Matrix.

Input	Output From Industry				
	1	2	3	----- n	n+1
1	$a_{11}X_1$	$a_{12}X_2$	$a_{13}X_3$	$a_{1n}X_n$	$a_{1,n+1}X_{n+1}$
2	$a_{21}X_1$	$a_{22}X_2$	$a_{23}X_3$	$a_{2n}X_n$	$a_{2,n+1}X_{n+1}$
3	$a_{31}X_1$	$a_{23}X_2$	$a_{33}X_3$	$a_{3n}X_n$	$a_{3,n+1}X_{n+1}$
n	$a_{n1}X_1$	$a_{n2}X_2$	$a_{n3}X_3$	$a_{nn}X_n$	$a_{n,n+1}X_{n+1}$
n+1	$a_{n+1,1}X_1$	$a_{n+1,2}X_2$	$a_{n+1,3}X_3$	$a_{n+1,n}X_n$	$a_{n+1,n+1}X_{n+1}$

We will apply variable λ_i to each sector in this way, to the last row.

$$n+1 \lambda_1 a_{n+1,1} X_1 \lambda_2 a_{n+1,2} X_2 \lambda_3 a_{n+1,3} X_3 - \lambda_n a_{n+1,n} X_n$$

$$\sum_{j=1}^n (X_j - a_{1j} X_j) - \sum_{j=1}^n \lambda_j a_{n+1,j} X_j$$

The equations are,

$$X_1 = a_{11} X_1 + a_{12} X_2 + \dots + a_{1n} X_n + a_{1,n+1} X_{n+1} + D_1$$

$$X_2 = a_{21} X_1 + a_{22} X_2 + \dots + a_{2n} X_n + a_{2,n+1} X_{n+1} + D_2$$

$$X_n = a_{n1} X_1 + a_{n2} X_2 + \dots + a_{nn} X_n + a_{n,n+1} X_{n+1} + D_n$$

$$X_{n+1} = a_{n+1,1} X_1 + a_{n+1,2} X_2 + \dots + a_{n+1,n} X_n + a_{n+1,n+1} X_{n+1} + D_{n+1}$$

Now our new $X_{n+1} = X_{n+1}^*$

$$\begin{aligned} X_{n+1}^* &= \lambda_1 a_{n+1,1} X_1 + \lambda_2 a_{n+1,2} X_2 + \dots + \lambda_n a_{n+1,n} X_n \\ &\quad + a_{n+1,n+1} X_{n+1} + D_{n+1} \\ &= \sum_{j=1}^n \lambda_j a_{n+1,j} X_j \end{aligned}$$

This will change our pollution elimination column. It was before,

$$\begin{aligned} & n+1 \\ & a_{1,n+1} X_{n+1} \\ & a_{2,n+1} X_{n+1} \\ & a_{3,n+1} X_{n+1} \\ & \dots \\ & a_{n,n+1} X_{n+1} \\ & a_{n+1,n+1} X_{n+1} \end{aligned}$$

Now it will be,

$$\begin{aligned}
& n+1 \\
& a_{1,n+1}X_{n+1}^* \\
& a_{2,n+1}X_{n+1}^* \\
& a_{3,n+1}X_{n+1}^* \\
& \dots \\
& a_{n,n+1}X_{n+1}^* \\
& a_{n+1,n+1}X_{n+1}^*
\end{aligned}$$

So for each industry, there will be a change in inter industry demand, (for the last column) and there is a change in the final demand sector of pollution. first it was zero., then for constant neutralisation factor model it was $(1 - \lambda) D_{n+1}$. Now it will be again change as $\sum_{j=1}^n (1 - \lambda_j) D_{n+1}$. Let us call it $D^*_{n+1} = X_{n+1} - X_{n+1}^*$

4.12.1 Empirical example for variable neutralisation model.

In our example,

Pollution created by agriculture = 2004.39.

Now apply neutralisation factor. Suppose $\lambda_1 = 50\%$. = 1002.2.

$a_{n+1,1}X_1$ will be neutralized.

Pollution created by industrial sector, 12592.35.

Apply $\lambda_2 = 25\%$, = 3148.03

$a_{n+1,2}X_2$, will be neutralised.

Pollution created by other sector, is = 3167.04.

Apply $\lambda_3 = 90\%$, = 2850.33.

$a_{n+1,3}X_3$, will be neutralised.

Remaining level of pollution by three sectors after partial neutralisation factor applied,

$$\sum_{j=1}^3 (1 - \lambda_j) a_{n+1,j} X_j,$$

$$1002.2 + 3148.03 + 2850.33 = 7000.57, \text{ remaining level of}$$

pollution or final demand for pollution = D_{n+1}

Now our new elimination level of pollution is, $X_{n+1}^* = 465.19$

Therefore our new pollution elimination column will be,

$$0.3 \times 7000.57 = 3228.9$$

$$0.4 \times 7000.57 = 2800.2$$

$$0.3 \times 7000.57 = 3228.9$$

$$10763.00 \quad \text{and final demand} = 7000.57$$

Our new table will be now,

	Agri.	Industry	Others	Pollution	F.D.
Agri.	16792	23468	2550	3228.9	57913
Industry	8081	51608	13595	2800.2	74170
Others	4202	21658	13901	3228.9	66339
Pollution	1002.2	3148.03	2850.33		7000.57
V.A.	72552	44548	68715		185815
Totals	100852	152207	101240		

Now again, $(I-A)^{-1} \times \text{F.D.} = X$

1.253	0.391	0.054	-0.548	57913
0.191	1.719	0.139	-0.787	74170
0.100	0.340	1.107	-0.498	66339
0.042	0.159	0.030	-1.085	7000.57

The results are, 104586.8

244582.5

352198.7

4653.3

With the help of these models we can now observe the different levels of outputs, at the different levels of elimination of pollution. So now a table at a glance.

No neutral ⁿ	25% neutral ⁿ	variable neutral ⁿ	100% neutral
$\lambda = 0$	$\lambda = .25$	$\lambda_1 = .50, \lambda_2 = .25, \lambda_3 = .90$	$\lambda = 1$
100723	104444.85	104586.80	105176.76
147449	242568.55	244582.50	253054.83
203016	350922.68	352198.70	357564.04
0	1873.49	4653.30	11688.62

Conclusion: We can notice here that as the % of pollution neutralisation increases the output levels increases. Also there are increasing levels of outputs for pollution elimination sector. When there is no elimination of pollution, then there is certain level of gross outputs. To eliminate 25% of pollution in all sectors there is an increase in outputs to eliminate that much of pollution. When there is 100% neutralisation, the economy have to increase a RS.4453.76 crs. in agriculture sector.

Rs.108305.83 crs. of increase in industrial sector. etc. Thus we have to consider this increase as negative income, because it goes to the pollution elimination sector

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CHAPTER 5

SUMMARY AND CONCLUSION

Once there was a time, when smoke was considered a sign of prosperity. Now the times have changed, and smoke has been considered as a greater sign of pollution. What are considered pollutants today were not necessarily considered such in past. Fifty years ago, arsenic was the only metal known to be the cause of cancer, today numerous metals and substances are known to be causes of cancer.

During the last two decades there is a greater awareness of the hazards of pollution. Now it becomes a major political issue, especially in developed industrial nations. At the same time man is using natural resources for the development process. But nature imposes limitations on all living beings. Man has to obey the laws imposed by nature. He is using natural resources as fast as he could, but the nature could not reproduce those resources at the same speed. This is precisely what is happening today. Air and water are getting polluted with industrial emissions and effluents, lakes are being destroyed by acid rain.

Economics is not only the science of production and distribution. It has also to take into account the ecological repercussions of economic activities that could affect both production and distribution.

For development, economist have to study a number of causes. For example, technological innovations, resource discovery and depletion and population growth. All these factors may cause

the economy to grow and change. Suppose agriculture sector advances enough so that some workers can turn from farming to other sector. This division of labour can produce economic growth. Then new problems may occur like, depletion of raw materials needed for many of the new activities, and environmental pollution resulting from energy used on a massive scale. This also may overtax the environmental capacity to absorb and recycle waste products. Thus increase in pollution and increase in the level of economic development are the two things which go simultaneously with each other. The economic growth has allowed production to reach a point at which depletion of resource supplies and pollution have become serious problems. Some writers claim that these environmental problems are inevitable results of growth in GNP or material living standards. They argue that the zero GNP growth is the only alternative to environmental decay. But not all activities entering into GNP create equal amounts of effluents or use equal quantities of resources. Recycling of waste is also possible.

Thus in the first chapter the relationships between growth and pollution, welfare and growth, pollution and environment are discussed. The important notion of depletion is also discussed. Depreciation is a notion which comes under the industrial section, for it's capital consumption, while depletion is a similar notion for natural resources. Depreciation actually explains the rate of capital consumption, over a period of time. The national income, available for consumption is obtained

as net value added by subtracting depreciation from gross value added. The problem here is that, why not the depletion is taken in to account, while calculating national income or net value added.

When one recognises the importance of problem of pollution the knowledge of it on both qualitative and quantitative accounts becomes crucial. In the second chapter the qualitative measures of pollution are discussed. These measures are studied under five heads. 1. Resource depletion, 2. Biological pollution, 3. Chemical pollution, 4. Physical pollution, 5. Social disruption. While resource depletion and chemical pollution are mainly due to industrial and mining activity, social disruption is caused mainly due to transport activity. Hence it is felt that the study of pollution related to growth is better studied with the help of various economic activities. It is known that pollution is created by the various economic activities, but the creation of pollution is not the same from all these sectors of the economy. So for the sectorial pollution five main sectors, that is 1. agriculture, 2. industry, 3. mining, 4. energy production and 5. Transportation are taken into consideration.

Social cost of environment is very difficult to obtain because it is complicated to calculate. For the calculation of social cost, the investigator has to take various variables, with the assumption of their interrelations, and an element of vagueness is involved. With the help of lower bounds and upper bounds and shadow prices, of the projects, the investigator can obtain the social cost and benefits to compare with.

In the next chapter, quantitative part at micro level is studied. Environmental disruption and social cost of environment should be taken into account as a measure of economic growth and development. To avoid the big social cost and environmental deterioration and at the same time to achieve growth, our primary aim should be to recycle and reuse discarded materials, avoid wastes and repair damage, that have already done to our environment. We have to bear some cost for that purpose. So it is better to check before handling any project the costs and benefits of the project. The cost benefit approach of use at the micro level approach. It studies at the levels of individual projects, activities. Identification of all relevant costs and benefits connected with collection of data, evaluation in money terms and submission of CBA are the four stages of CBA. CBA while focusing on the environmental factors, is categorised in three parts. Viz. 1. Impact on human health, 2. Impact on materials and 3. Impact on natural resources.

There are several problems in application of CBA. Environmental impact assessment (EIA), can be usefully introduced, and added to CBA. There are limitations in application of CBA, which were discussed in the third chapter.

It has been noticed that all these solutions for environmental problems are at the micro level. But these are the problems, that should be thought at macro level, because the repercussions of one industrial effluents can affect the environment miles away from that industry. But at macro level there is little work done on this. Very few economists have tried

to measure the cost of pollution. Among them W. Leontief, has tried to quantify those costs and assess their impact at the sectoral and overall level of the economy.

In the first part of the fourth chapter, the review of those models have been taken. In the second part of the same chapter, the model has been developed in such a way that the cost of pollution has been accounted for in the calculation of national income. We had seen that as the cost of pollution increases, the gross output levels are increased, but there is no increase in national income. To eliminate pollution each sector of the economy has to produce more.

First, the normal $n \times n$ sector economy in the input output frame, is developed. After that, pollution sector has been introduced by an addition of one row and column. That is the dimension of the model is increased to $n+1$. Pollution row indicates the output of pollution from each sector and pollution column indicates the inputs required for the elimination of pollution by each sector. The development has been carried out by endogenising the pollution sector in the standard input output frame.

For the empirical example the source is the I-O transaction table for 1983-84. For the simplicity of the model the data has been consolidated into three sectors: Agriculture, industry and others. The data for pollution sector, is based on the perception and is illustrative in nature.

The problem can be visualised as the reduction in pollution level alone, which reduces the national income and consequently the disposable income to the society. Therefore an approach which sustains the same levels of final demand together with pollution has been developed. As it is always not possible and desirable also to maintain the existing levels of pollution a neutralization factor " α " is introduced.

We can give any value to " α ", between 0 and 1, and form the solutions. Also this " α " can be taken uniform to all sectors or variable across different activities, depending on the nature of the economy.

We can observe that as the pollution elimination cost increases the gross output levels are increased, but national income does not, thus the pollution actually has the adverse effect on National income.

Our illustrative example though is based on 1983 -84 input output table for the Indian Economy, the coefficients of pollution row and column, do not have any sound basis and are in the nature of guesses. Much work to be done to arrive at those coefficients. The impact of pollution on the costs, income generated and the prices at the sectoral level and the inter relationship among different sectors used to be analysed for the Indian Economy.

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