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Environmental Degradation and Measures for Its Mitigation with Special Reference to India's Agricultural Sector*

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I

INTRODUCTION

The term, 'environment', has many connotations. In this paper, by 'environment', we mean the natural environment, which encompasses all the biotic and abiotic elements that form our surroundings, that is, the air, the land, the water, the forests, the seas, the animals, and all other living and non-living elements of this planet Earth. Without the environment, none of us can survive. The environment performs the following four functions, which are essential for our survival and well being: (i) provision of 'natural goods' like air, solar energy, lakes, landscape, and wildlife; (ii) supplying natural resources such as land, water, forests, and minerals, which are used to create economic goods; (iii) functioning as a 'sink' into which the by-products of economic activities are dumped/discarded; and (iv) providing environmental services and amenities such as the maintenance of a habitable biosphere, including the stratospheric ozone layer, climate stability and genetic diversity, and recreation and aesthetic appreciation.

In India, more than three-fourths of its population depends directly for their livelihoods on activities based on natural resources and the remainder of the population relies on these resources indirectly for food, fuel, industrial output and recreation. Their economic well-being is inextricably tied to the productivity of natural resources and quality of environment. Sadly, most of the natural resources including environment in India are in a serious state of degradation. For example, agricultural lands suffer from soil erosion, water-logging, salinity and general loss of fertility, making them less productive. Similarly, groundwater aquifers are over-exploited in many arid and semi-arid areas, surface water sources are highly polluted and consequently water for drinking and irrigation is increasingly getting scarce and polluted. Fishery yields are declining, and air quality is deteriorating. Increasing levels of air, water and land pollution pose a serious threat to human health and longevity. Good management of natural resources and environment is essential to

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attain and sustain economic growth and development. It is not, as is sometimes mistakenly asserted, just a luxury for wealthy countries concerned with aesthetics. It is imperative for sustainable livelihoods of the poor to enhance and sustain the productivity of natural resources, arrest environmental degradation, and protect the integrity of eco-systems.

In this paper, we first present an overview of the type and extent of degradation of environment as it affects India's agricultural sector, then identify the underlying causes of degradation and finally discuss the measures that could be used for mitigating the problem of environmental degradation.

II

TYPE AND EXTENT OF ENVIRONMENTAL DEGRADATION

Environment keeps changing over time naturally and it is also amenable to changes by human beings. Thanks to scientific and technological developments, our ability to alter the environment has increased tremendously, whereas the capacity of environment to cope with those alterations is limited. The nature's bounty and abundance are disappearing at a rapid rate now in many regions of the world including India due to the human alterations of the environment. All this has brought to the fore the need for protection and preservation of environment and the urgency of developing sound environmental policies and programmes. Without them, development would not only be unsustainable but would be tantamount to retrogression. The challenge of creating and maintaining a sustainable environment is probably the single most pressing issue confronting us today and will remain so in the foreseeable future (Raven *et al.*, 1998).

Now we briefly present an overview of the type and extent of environmental degradation in India with special reference to land, water, fisheries, biodiversity, and climate change.

2.1 *Land Degradation*

The Department of Land Resources, Ministry of Rural Development, and Government of India has identified different types of degraded wastelands and have prepared a Wasteland Atlas of India for the year 2000, with the help of Indian Remote Sensing Satellites. According to their estimates, the degraded wastelands accounted for 20.16 per cent of India's total geographical area. The degraded lands include several types of land such as gullied and/or ravinous land, water-logged and marshy land, land affected by salinity and/or alkalinity, degraded pastures/grazing land, degraded notified forest land, mining industrial wasteland, eroded steep sloping land, sandy and desertic lands, and barren rocky/stony wastelands. Whatever the type of degradation, a common characteristic of degraded lands is that their productivity is

almost negligible but it could be restored through proper reclamation measures and management.

It is estimated that in India in 1994, about 188 million hectares (ha) of land, which is 57 per cent of the country's total geographical area of about 329 million ha, was degraded. Of the 188 million ha of degraded land, about 149 million ha was affected by water erosion, 13.5 million ha by wind erosion, about 14 million ha by chemical deterioration and 11.6 million ha by water-logging (Sehgal and Abrol, 1994). A recent survey by the National Bureau of Soil Survey and Land Use Planning revealed that 66 per cent of India's total geographical area (around 192 m ha) was at varying stages of degradation (quoted in Haque, 1997).

Land degradation has significant adverse impacts on crop productivity and the environment. Joshi and Jha (1991) in a study of four villages in Uttar Pradesh found that about 50 per cent decline in crop yields over a period of eight years was due to salinity and water -logging caused by the irrigation system.

2.2 *Degradation of Water Resources*

Water is a finite but renewable natural resource, and, like other natural resources, it is an integral part of the environment. It is essential for survival of all living beings on this planet and so also for socio-economic development of households, communities and nations all over the world. It is also necessary to maintain and enhance the biodiversity and quality of environment. Water resources of India are under great biotic and abiotic pressure. Most of the rivers, lakes, tanks and ponds are polluted and the groundwater aquifers are being over-exploited in most of the arid and semi-arid regions and are on the verge of complete exhaustion/depletion. For example, according to a report prepared by the Central Groundwater Board, the annual withdrawal of groundwater in Calendar East Block of Jalandhar district of central Punjab exceeds the annual recharge by 350 per cent (Johl, 2006; p.607). Besides, in many areas the groundwater aquifers have been polluted/contaminated. Droughts and floods also have been a bane of India's economy since time immemorial. All these factors together have adversely affected the quality of environment.

Pollution of surface water resources, particularly lakes, rivers, and tanks/ponds and degradation of quality of groundwater have assumed worrisome proportions now in India. The surface water is hardly fit for drinking. The river Ganga, which is worshipped by devout Hindus as "Mother Ganga" is no exception; it is highly polluted at several places.[1] Similarly, groundwater in many arid and semi-arid areas has been depleted due to over-extraction and degraded due to leaching of fertilisers and pesticide residues from cultivated fields. Consequently, the incidence of waterborne diseases has increased significantly in recent years.

The Centre for Science and Environment, New Delhi (CSE, 2001) in a special issue, *"Survival Primer'*, of its fortnightly magazine, *Down to Earth*, has carried stories of pollution of environment, particularly pollution of Damodar river,

pollution of Lake Kolleru in Andhra Pradesh, pollution of river Yamuna, air pollution, and degradation of India's rangelands. The space available here does not permit us to present even a summary of the stories published. But the sum and substance of the stories is that India's natural resources and environment have been subjected to all kinds of misuse, misappropriation, wastage, and degradation, rendering the quality of environment unfit for a healthy and safe living. The extent of degradation of India's water resources has reached a stage when immediate intervention by the governmental and non-governmental agencies through appropriate measures has become absolutely essential. It seems to us that the social benefits from such interventions will be markedly higher than their social costs.

The natural and man-made disasters have been a bane of India's economy since time immemorial. In ancient Indian literature, there are references to natural disasters such as prolonged droughts, flash floods, hail storms, land slides, cyclones and forest fires. About 60 per cent of the landmass in India is vulnerable to earthquakes; over 40 million hectares (ha) is prone to floods;[2] about 8 per cent of the total area is prone to cyclones; and about 68 per cent of the total area is susceptible to droughts. About eight thousand kilometre-long coastline is prone to severe cyclonic formations. About 55 per cent of the total area lies in Seismic Zones III-V and is vulnerable to earthquakes. The sub-Himalayan regions and Western Ghats are vulnerable to land slides (Kanwar, 2001; p.7, and Government of India, 2004a, p.32).

Water-logging and salinity are two of the serious problems in many of the canal command areas in India. According to an estimate made by a Working Group constituted by the Government of India in 1991, an area of about 2.46 million ha in 42 different commands in 15 states is affected by the problem of water-logging and salinity in the irrigated canal commands in India (Government of India, 1991). Among the states, Bihar is worst-affected by water-logging problem followed by Uttar Pradesh, Andhra Pradesh and Haryana. Incidentally these are the states where canals have been the major source of irrigation.

2.3 *Degradation of Fisheries*

The fisheries sector occupies an important place in the socio-economic development of India. It is a source of cheap and nutritious food and is an important foreign exchange earner.[3] Besides, it is considered as a major source of livelihood to 11 million people in the country, engaged fully, partially, or in subsidiary activities pertaining to the sector. It is estimated that fisheries sector alone can provide one million jobs in the next five years.

The fisheries sector of India comprises two sub-sectors, namely, marine fisheries and inland fisheries, including freshwater and brackish water aquaculture. Over-fishing is a serious problem in the coastal areas of India, particularly Kerala. The problem of declining yield is now perceived in many inshore waters also which were previously high yielding and supporting large numbers of traditional fishermen.

Although the real causes of this phenomenon are difficult to identify, generally new fishing technology characterised by mechanised trawlers is blamed for this. The technologies which are available to fisher folk today are much more powerful. Fishing hauls which once took days to recover now take a few minutes. The traditional trawlers used long steel lines and stout nets which were either dragged mid-water or across the dark ocean floor eased on the way by rollers and drums. Today they have been replaced by bigger and faster ships equipped with thinner but stronger lines and wider drums. The maws of the trawlers can be enormous, often hundreds of feet wide. What was earlier military technology is now being applied for hunting fish. Radars are used to navigate boats through dense fog, sonars are used to hunt deep shoals and navigation satellites direct the boats into rich localities. This has resulted in the depletion of life from many continental shelf regions and shallow seas, and now the nets are plunging still deeper.

With the increase in the number of mechanised trawlers in the late seventies in Kerala, the total catch of marine fish has declined significantly, with the mechanised sector capturing a lion's share in the declining catches. An analysis of the catches revealed that many demersal species had declined, indicating over-fishing by the trawlers. The trawlers had also damaged the natural habitat of fish like corals and small reefs, leading to the depletion of fish stock in coastal waters (Singh, 1994b, p.91).

Fisheries are vulnerable to cyclones and high sea tides. For example, in Orissa, soon after the Super Cyclone of 2001, the entire sea coast was adversely affected by high sea tides. This led to, among other things, degradation of fisheries and decline in fish catch. The South East Asia tsunami of December 2004 adversely affected marine fisheries in the coastal areas of Kerala, Tamil Nadu, and Karnataka. Due to the bottom of the sea coming up very close to the sea surface during the course of occurrence of the tsunami, most of the fishes either perished and those which survived migrated to other areas.

The main challenges facing the inland fisheries sub-sector in India are the lack of any scientific assessment of fishery resources and their potential in terms of fish production, low productivity, lack of eco-friendly modern technologies for harvest and post-harvest operations, pollution of fisheries leading to the fall in fish production, and inadequate infrastructure facilities for processing and marketing.

2.4 *Loss of Biodiversity*

The term, 'biodiversity', or 'biological diversity' refers to the total variation in all forms of life on earth or within a given area or ecosystem, typically expressed as the total number of species found within the area of interest or the genetic diversity within a species. There are three main types of biodiversity, namely, genetic diversity, species diversity, and ecosystem diversity. Genetic diversity refers to total genetic information contained in all the animal, plant, and microorganism species on

earth. Species diversity refers to the number of species within a system, or a given area. Ecosystem diversity means the number of habitats, biotic communities, and ecological processes in the biosphere as well as the extent to which ecosystems vary.

There are no reliable estimates of the extent of biodiversity available worldwide. The estimates vary from 2 million to 100 million species with the best estimate of somewhere near 10 million. Only 1.4 million have actually been named so far. As one of the world's oldest and largest agricultural countries, India has an impressive diversity of crop species and varieties. It is rated as one of the 12 mega-diversity countries in the world accounting for 60-70 per cent of the world's biodiversity. The areas on the planet with exceptionally high biodiversity are known as biodiversity hotspots. India has two of the world's twenty-five biodiversity hotspots, namely, the western Ghats and the Eastern Himalayas (Source: www.conservation.org). It has 6 per cent of the world's flowering plant species, 14 per cent of the world's birds, one-third of the world's identified plant species numbering over 45,000 and about 81,000 identified species of animals (World Bank, 1996, p.1).

Like other natural resources and environment, biodiversity in India also has been under great biotic pressure for decades now. India's high levels of human and domestic animal populations, their high density and rapid growth, high rate of urbanisation and industrialisation, commercialisation of agriculture, high incidence of poverty and high level of illiteracy have all contributed to the degradation of natural resources and environment, and loss of biodiversity. Many plant and animal species are on the brink of extinction. It is high time that India adopted a responsible national policy of natural resources management and biodiversity conservation, which is in tandem with its economic and social development policies.

2.5 *Climate Change*

The term, climate, is generally used to connote a complex natural phenomenon comprising variables such as air temperature and humidity, wind, and precipitation. Although the climate remains fairly stable on the human time scale of decades or centuries, it fluctuates continuously over thousands or millions of years and is affected by a large number of variables (Cunningham *et al*., 1999, p.195). There have been perceptible changes in the climate all over the world, particularly in the last two decades or so. The climate change and its adverse impacts on the environment, human health and the economy have recently risen to the top of the economic and political agenda in various national and international forums and meetings on environment. As some of the climatic changes are attributable to human activities and therefore change in human behaviour can be an important instrument of minimising the extent of those changes in the climate which have harmful effects. The most important climatic changes that have come to the fore recently and that are harmful include acid rain, global warming, and depletion of stratospheric ozone shield or layer. Besides, such climatic aberrations as floods, droughts, cyclones, and

tsunamis also cause serious damage to humans and have adverse effects on local, regional and global climate.

The acid rain adversely affects the plants, fishes and birds and corrodes metals and building materials. The effects of acid rain have been recorded in parts of the United States, the erstwhile Federal Republic of Germany, Czechoslovakia, the Netherlands, Switzerland, Australia, Yugoslavia and elsewhere. It is also becoming a significant problem in Japan and China and in Southeast Asia. Rain with a pH of 4.5 and below has been reported in many Chinese cities. Sulphur dioxide emissions were reported in 1979 to have nearly tripled in India since the early 1960s, making them only slightly less than the then-current emissions from the Federal Republic of Germany (http://www.geocities.com/narilily/acidrain.html).

According to the National Academy of Sciences, the Earth's surface temperature has risen by about 1 degree Fahrenheit in the past century, with accelerated warming during the past two decades. In 1980, the mean global temperature was 15.18^0 C; it increased to 15.38^0 C in 1990, 15.39^0 C in 1995 and 16.04^0 C in 2005. In fact in the northern hemisphere, 2005 was the warmest year ever recorded with an increase in the mean global temperature of the order of + 0.65^0 C over the period, 1995-2005. Increasing concentrations of greenhouse gases are likely to accelerate the rate of climate change. Scientists expect that the average global surface temperature could rise 0.6 -2.5°C in the next fifty years, and 1.4 - 5.8°C in the next century, with significant regional variations. Evaporation will increase as the climate warms, which will increase the average global precipitation. Soil moisture is likely to decline in many regions, and intense rainstorms are likely to become more frequent (http://www.epa.gov/ozone/intpol/index.html).

Global warming has several adverse effects on human health, and agricultural production. It leads to increase in heat-related diseases and deaths. Besides, it also indirectly affects human health due to higher incidence of malaria, dengue, yellow fever and viral encephalitis caused by expansion of mosquitoes and other disease carriers to warm areas. The adverse effect on agricultural production is due to increased frequency of droughts, floods and hurricanes and increased incidence of pests, causing shortage of food.

Within the stratosphere, a concentration of ozone molecules makes up the ozone layer. Around 90 per cent of the ozone is within the ozone layer. The ozone layer could be thought of as the Earth's sunglasses, protecting life on the surface from the harmful glare of the sun's strongest ultraviolet rays, which can cause skin cancer and other maladies. The stratospheric ozone layer filters ultraviolet (UV) radiation from the sun. As the ozone layer is depleted, more ultraviolet radiation reaches the earth's surface (Raven *et al*., 1998, pp.471-475). There are reports of large ozone holes opening over Antarctica, allowing dangerous UV rays through to Earth's surface. Indeed, the 2005 ozone hole was one of the biggest ever, spanning 24 million sq km in area, nearly the size of North America. While the ozone hole over Antarctica continues to open wide, the ozone layer around the rest of the planet seems to be on

the mend (Source: http://www.sciencedaily.com/releases/2006/05/060527093645.htm). Over-exposure to UV rays may cause several health hazards for humans; skin cancer being the most widely known disease. In addition, over-exposure to UV rays can also cause cataracts.

III

CAUSES OF ENVIRONMENTAL DEGRADATION

Environmental degradation to some extent is an inevitable consequence of natural processes and human activity. For example, land degradation can result from both the intrinsic attributes such as location, environment, and chemical and physical properties of the soil as well as from man-made circumstances. Any exploitation and use of non-renewable resources such as land inevitably results in their partial or total depletion, as well as the degradation of the landscape and generation of waste. Agricultural extensification leads to deforestation, cultivation of marginal lands, and soil erosion while agricultural intensification leads to pesticide and fertiliser run-offs, water-logging, and soil salinity.

In this section, we identify and briefly discuss the major factors that cause environmental degradation. Some of the causes are common to all types of degradation whereas the others are specific to particular types of degradation.

3.1 *The Economic Logic*

A characteristic feature of environment is the preponderance of common pool resources (CPRs), i.e., the resources which are used in common by identifiable groups of people irrespective of whether they are owned by them or not, and open access resources (OARs), i.e., the resources that are accessible to every one without any restrictions; they are nobody's property. Examples of CPRs include village grazing lands, public lands along highways and railways, ponds, rivers, groundwater basins, community inland fisheries and marine fisheries within the Exclusive Economic Zones (EEZs) of nations. The OARs include air sheds, solar radiation, high sea marine fisheries beyond the EEZs, space, ozone layer, and biodiversity. All CPRs and OARs suffer from what Hardin (1968) called, "the tragedy of the commons".

The logic of the 'tragedy' is purely economic and can be stated as: unregulated access to a CPR or an OAR creates a decision-making environment in which incremental private benefits to an individual from the increased use of the resource markedly exceed the incremental private costs associated with the increased use. Under these circumstances, each rational consumer or user of the resource is motivated to consume or use more and more of the resource till the resource is completely destroyed or degraded as a result of collective and uncoordinated use by all the individuals in the community. Thus, the individual rationality leads to collective irrationality. The calculus of incremental or marginal private benefits

markedly exceeding the incremental private costs follows from the fact that, in the case of a CPR or an OAR, whereas an individual can appropriate all the benefits resulting from his increased use of the resource, he bears only a small fraction of the incremental costs associated with his increased use; the incremental costs are shared by all the members of the community (Singh, 1994a, pp.12-14). This means that there exists an externality in the use of the CPR in question as evident from the difference between the incremental private cost and the incremental social cost; the former being less than the latter. Thus, the common pool problem is basically one of the existence of externality - a divergence between private cost and social cost of exploitation which eventually leads to either depletion or overcrowding or congestion (Friedman, 1971, p.855). The problem is a manifestation of either the absence of exclusive private property rights or the breakdown of the structure of property rights (Randall, 1975, p.734).

Hardin's thesis of the 'tragedy of the commons' has since become the dominant paradigm of the exploitation of CPRs and OARs. It has formed the basis of numerous policies seeking to privatise or nationalise natural CPRs in many developed and developing countries of the world. It is now widely agreed that the co-users of CPRs and OARs usually fail to co-operate in using the resource optimally under the following three conditions:

1. When the perceived private costs to individuals of cooperating may exceed the perceived private benefits of co-operating;
2. When the individuals feel that their own contribution to the collective goal is minuscule and would not be missed if withheld because the others will continue contributing, enabling them easily to free ride on the contributions of others; and
3. When individuals have no assurance or certainty that the other members of the group will make their contributions (or cooperate) and that their lone contribution to the effort would be sufficient to produce the desired outcome.

When an externality is present, the competitive equilibrium use of the resource (CPR and OAR) is socially inefficient (Dasgupta, 1982, pp.19-23 and Singh, 1994a, pp.26-31). This is illustrated in Figure 1. As shown in the figure, the competitive equilibrium level of grazing (X) in a community pasture is attained when the level of grazing is X_2 where the private marginal cost is equal to the marginal revenue whereas the socially optimum level of grazing is X_1, where the social marginal cost is equal to the marginal revenue. Thus, the open access equilibrium is attained at a higher level of grazing and hence a higher level of exploitation than the socially optimum level of exploitation, i.e., $.X_2 > X_1$.

The problem of non-cooperation of users of CPRs and OARs could also be illustrated through the Prisoners' dilemma (PD) game (Singh and Shishodia, 2007, pp.100-102).

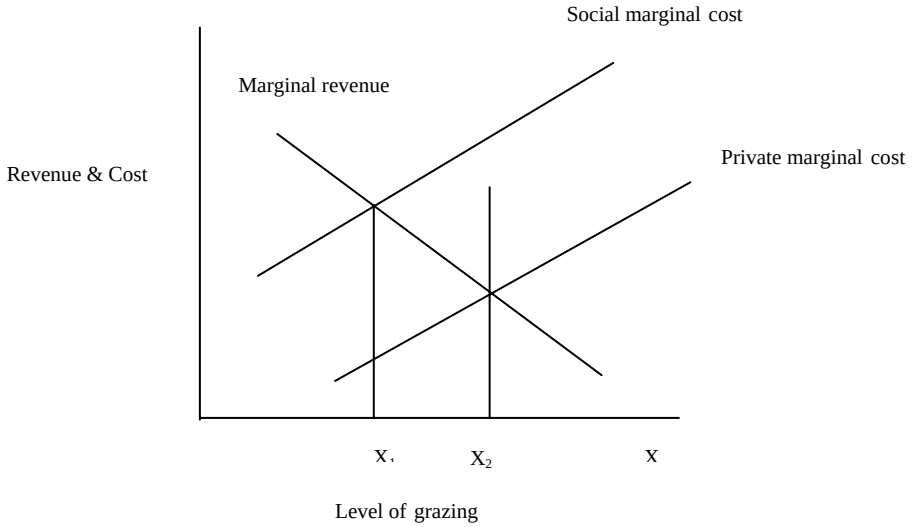

Figure 1: Competitive (Open Access) Equilibrium Level and Socially Optimal Level of Grazing in a Village Pasture

3.2 *Socio-Economic Factors*

Besides the pure economic logic, there are several other socio-economic factors such as population pressure, poverty, unemployment, ignorance, and lack of incentives for using the environment in a socially optimum manner on sustainable basis. So long as the human and animal population was within the carrying capacity of locally available natural resources and local environment, there was no environmental degradation due to human actions. But as the population increased and local economies got integrated with external economies through trade, the process of degradation of natural resources and environment started. The need to meet the increasing demand of rapidly increasing human population for food, fibre, and other agricultural commodities has necessitated the intensification and chemicalisation of agriculture, leading to degradation of land and decline in its productivity. Further, the fact that many communities who depend directly on natural resources for their livelihood are very poor, ignorant, and have no alternative employment opportunities means that they are compelled by their circumstances to over-exploit and degrade the natural resources accessible to them. Illicit felling of trees from forests, hunting, encroachment of forest land, and poaching are some of the activities resorted to by the communities, partly driven by their basic needs and partly by greed. This might happen even if it is to the longer-term detriment of the communities' own well being.

Another important economic reason for environmental degradation is the fact that protection and conservation of environment has a high opportunity cost, especially in developing countries like India. For instance, in the case of forests, the opportunity

cost is the value that could be derived by clear-cutting the timber and using the forest land for agricultural purpose, or as a site for a hydropower project. Likewise, the opportunity cost of conservation of a marine ecosystem is the value that could be derived from depleting the entire fish stock to extinction. In view of this, the local resource users do not have any incentive to protect and conserve the environment.

3.3 *Technological Factors*

Another major reason of environmental degradation in India is the fact that beginning the mid-1960s, there have been many technological breakthroughs in the agricultural sector, which ushered in the so-called "Green Revolution". For example, there has been widespread adoption of high yielding varieties of crops for few major foodgrain crops such as rice and wheat in conjunction with increased use of water, chemical fertilisers and plant protection chemicals. This has led to the increasing uniformity within those species and varieties of crops and hence the loss of biodiversity and increased levels of degradation of land due to excessive irrigation and pollution of water bodies due to leaching of harmful residues of chemical fertilisers and pesticides. Increasing use of tractors and other farm machinery in agriculture is causing air pollution. Besides, development and widespread use of water extracting devices such as drilling machines and power-operated submersible pumpsets has led to the over-exploitation of groundwater basins and development of mechanised trawlers to over-fishing of marine fisheries and pollution of sea water.

3.4 *Liberalised International Trade in Agricultural Commodities*

In the wake of the new world trade regime ushered in by the World Trade Organisation (WTO) in 1995, international trade has been Liberalised and freed from various kinds of tariff and non-tariff regulations. India, being a member of WTO, is bound to abide by the new rules of the international trade. International trade in agricultural commodities affects environment both directly and indirectly. By inducing the export demand, it provides incentives to producers through increased prices to increase their production. The producers normally respond by using chemical fertilisers, pesticides, and irrigation water at higher rates to increase their production. This degrades the quality of natural resources and environment. It is a bit too early to assess the impact of Liberalised international trade in agricultural commodities on environment in India. But the evidence available to us proves that the export-led increase in the catch of fish and in rice production have both had an adverse effect on the environment (Singh and Shishodia, 2007, pp.300-301).

The increase in rice production, especially fine variety rice such as *basmati*, in response to higher world prices and the export- promoting measures taken by the government has led to the problems of water-logging and soil salinity in many areas in Punjab, Haryana, and Western Uttar Pradesh which produce fine variety rice for

export. In view of this, there is need for government action to regulate the international trade in those agricultural commodities whose production leads to environmental degradation directly or indirectly (Singh, 1994c, pp. 89-102).

Besides, the international economic relationships also pose a particular problem for countries like India trying to manage their environments, since the export of natural resources-intensive commodities constitute a large part of their economies. The processing of certain raw materials - pulp and paper, oil and alumina, for example, can have a substantial environmental side-effects. The industrial countries have generally been more successful than the developing ones in seeing to it that the export product prices reflect the cost of environmental damage and of controlling that damage. Thus in the case of exports from industrial countries, these costs are paid by consumers in importing nations, including those in developing countries. But in the case of exports from developing countries, such costs continue to be borne entirely domestically, largely in the form of damage costs to human health, property and environment.

Daly (1973) argues that in a free trade regime, a country that internalises the costs of using natural resources including environment into its prices will be at a disadvantage vis-à-vis a country that does not, since its prices will be higher. Therefore, there will be no incentives for any country to internalise environmental costs and thereby attain sustainable development in an open trading system.

IV

MEASURES FOR MITIGATION OF ENVIRONMENTAL DEGRADATION

The possible measures for mitigating the problems of environmental degradation could broadly be classified into four categories, namely, institutional changes, direct controls, and economic/market-based instruments and technological measures. We could also classify the measures into ‘preventive measures’ and ‘curative/remedial measures’. The former could be used to prevent or minimise the extent of degradation and the latter to cure or remedy the damage caused by degradation. But as an old adage goes “prevention is better than cure”, we should attach a higher priority to ‘preventive measures’, than ‘curative measures’.

When identifying the alternatives for mitigating the problems of environmental degradation, we should aim at minimising it, or at least restricting it to a level consistent with the society’s objectives, rather than trying to prevent or eliminate it altogether. A simple rule of thumb for choosing a particular measure is that its estimated social benefits must markedly exceed its estimated social costs.

We now briefly discuss the merits and demerits of major instruments in each of the four categories.

4.1 *Institutional Instruments*

Constitutional provisions, creation of new institutions, modification of existing institutions, changes in existing systems of property rights, enacting new laws, imposing new taxes, and provision of newly introduced subsidies belong in the category of institutional changes. These instruments usually take a long time to be promulgated and produce the desired effect. They are generally good for solving long-term structural problems. They belong in the category of 'preventive measures'.

Article 48-A of the Constitution of India provides that the state shall Endeavour to protect and improve the environment and to safeguard the forest and wildlife of the country. Article 51-A imposes as one of the fundamental duties on every citizen the duty to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures.

The present legislative framework for environment management in India is broadly contained in the umbrella Environment Protection Act 1986, the Water (Prevention and Control of Pollution) Act, 1974, the Water Cess Act 1977 and the Air (Prevention and Control of Pollution) Act, 1981. The laws in respect of management of forests and biodiversity are contained in the Indian Forest Act 1927, the Forest (Conservation) Act 1980, the Wild Life (Protection) Act 1972 and the Biodiversity Act 2003. There are several other enactments, which complement the provisions of these basic enactments.

Now, India has a large number of environmental acts, rules, regulations and policies. Pollution limits for various industries have been prescribed in the Environmental Protection Rules 1986. Environmental clearance from the Union Ministry of Environment and Forests is mandatory for setting up new industries in many sectors. The first national policy for managing (marine) fisheries was announced by the Government of India in 2004. This was a good step as an enabling institutional framework for proper management and control of the fisheries sector. The 2004 Policy provides for reviewing the existing legal framework for regulating the fishing operations. It also envisages the introduction of additional legal instruments in such areas as operation of Indian flag vessels in the EEZ, introduction of new fishing units, ensuring conservation of marine resources, especially in limited access fisheries, and fishery harbour management (Government of India, 2004b).

A list of major environmental acts and rules now in force in India can be found in the website: http:// www.envfor.nic.in). All those acts and rules seek to provide incentives for reducing the pollution from various sources and disincentives for those firms, which pollute. What is needed, however, is more strict enforcement of all these acts and rules. The present approach to dealing with environmentally unacceptable behaviour in India has been largely based on criminal processes and sanctions. Although the criminal sanctions, if successful, may create a deterrent impact, in reality they are rarely fruitful for a number of reasons. On one hand, giving lower level officials the power to institute criminal prosecutions may

provide fertile opportunities for rent-seeking. Civil law, on the other hand, offers flexibility, and its sanctions can be more effectively tailored to particular situations. The evidentiary burdens of civil proceedings are less daunting than those of criminal law. It also allows for preventive policing through orders and injunctions to restrain prospective polluters. Accordingly, the National Environment Policy-2006 (NEP-2006) recommends a judicious mix of civil and criminal processes and sanctions in the legal regime for enforcement, through a review of the existing legislation (Government of India, 2006). Civil liability law, civil sanctions, and processes would govern most situations of non-compliance. Criminal processes and sanctions are suitable for dealing with serious, and potentially provable infringements of environmental laws, and their initiation should be vested in responsible authorities. Recourse may also be had to the relevant provisions in the Indian Penal Code, and the Criminal Procedure Code.

As we know, most of the problems of environmental degradation arise because of the open access or common pool nature of the environment. In view of this, where technically feasible and economically viable, transforming the open access and common pool environmental resources into some sort of state or private property through the creation of property rights could resolve the problems of environmental degradation. An example of use of this measure is the privatisation of degraded revenue lands (state property) and village common lands (CPRs) in West Bengal through granting of land *pattas* (leases) to individuals. This has helped resolve the problem of their degradation and transformed those lands into productive private property (Singh, 1994a: pp.149-163 and Singh and Shishodia, 2007, p.221).

4.2 *Direct Controls and Regulation*

Direct controls include quantity quotas, seasonal restrictions, safe minimum standards, price controls, prohibition of certain socially undesirable practices by government and courts, and so on. They are powerful tools of environment management, can take effect quickly, and can be selective. They belong in the category of ‘preventive measures’. They are good for use in dealing with short-term environmental problems but less effective in resolving long-term or structural problems. Their enforcement and monitoring could be very costly and could lead to corruption.

Conventionally, direct controls, or regulations are given effect through governmental orders, or pronouncements by judiciary. In certain cases, laws also are enacted which stipulate that, for instance, you are not allowed to pollute the air above a certain level and if you do, you will be fined, or imprisoned, or both. This form of intervention has high costs of administration and compliance, is often inflexible and provides little incentive for innovation to reduce environmental degradation. For all these reasons, the use of regulatory instruments in isolation from other measures is unlikely to be the least-cost method of achieving environmental objectives in many cases. Control and regulation compares unfavourably with the use of market-based

approaches such as taxes and emission charges. Despite its weaknesses, control and regulation is still the predominant instrument for addressing the environmental problems in most countries, including India.

Several significant orders have been issued by the Supreme Court (SC) of India and the High Courts from time to time directing the Union and State Governments to take action to protect the environment.[4] The court orders have in fact been more effective than the government fiats in most of the cases.

4.3 *Environmental Standards*

Environmental standards refer both to the acceptable levels of specified environmental quality parameters at different categories of locations (ambient standards), as well as permissible levels of discharges of specified wastes into streams by different classes of activities (emission standards). They belong to the category of 'preventive measures'.

It is now well understood that environmental standards cannot be universal, and each country should set the standards taking into account its national priorities, policy objectives, and resources available. These standards could be revised to become more stringent, as a country develops, and has greater access to technologies and financial resources for environment management. Environmental standards also need to relate to other measures for risk mitigation in the country, so that a given societal commitment of resources for achieving the overall risk reduction yields the maximum aggregate reduction in risk.

Similarly, the emission standards for each class of activity need to be set on the basis of general availability of the required technologies, the feasibility of achieving the applicable environmental quality standards at the location (specific or category) expected to be impacted by the proposed emissions standards, and the likely unit costs of meeting the proposed standard. It is also important that the standard is specified in terms of quantities of pollutants that may be emitted, and not only by concentration levels, since the latter can often be easily met through dilution, with no actual improvement in ambient quality. The tendency to prescribe specific abatement technologies should also be eschewed, since these may unnecessarily increase the unit and societal costs of achieving the ambient environmental quality, and in any case because a technology that is considered ideal for meeting the given emission standards may not be acceptable on other relevant parameters, including possibly other sources of societal risk.

The NEP -2006 advocates the following three specific measures to improve the effectiveness of environmental standards (Government of India, 2006):

(i) Set up a permanent machinery comprising experts in all relevant disciplines to review the notified ambient and emissions standards in the light of new scientific and technological information as they become available, and changing national circumstances, ensuring adequate participation by potentially impacted communities, and industry associations;

(ii) Strengthen the network for monitoring ambient environmental quality, including monitoring through participation by local communities, and public-private partnerships; and

(iii) Progressively ensure real-time, and on-line availability of the monitoring data.

4. 4 Economic Instruments[5]

This set of instruments affect the costs and benefits of alternative actions open to economic agents, and thereby influence the behaviour of decision makers in such a way that the alternatives are chosen that lead to an environmentally more desirable situation than in the absence of the instrument. Economic instruments aim to bridge the gap between the private and social costs by internalising all external costs to their sources, namely, the producers and consumers of resource depleting and polluting commodities. Such instruments are often referred to as market-based instruments, as they work by using market signals such as prices, emission charges/taxes, and subsidies to encourage socially better decisions. They belong to the category of 'preventive measures'.

Taxes or subsidies for environmentally sound production can be used for full cost pricing of production and consumption. For example, the current prices of canal irrigation water do not reflect the social cost of water. The effects of canal irrigation on soil and human health (through water-borne diseases) are not considered at all. Fiscal instruments therefore try to bridge the gap between the private and social cost of production and consumption. Ideally, the taxes or subsidies should be equal to the marginal environmental damage caused by a certain activity. If this were the case, it would adjust the price of a good exactly by the amount of reduction in social welfare caused by the externalities associated with such a product.

The current near exclusive reliance on instruments of command and control for environmental regulation in India does not permit individual actors to minimise their own costs of compliance. This leads, on one hand, to non-compliance in many cases, and unnecessary diversion of societal resources from other pressing needs, on the other. Economic instruments work by aligning the interests of economic actors with environmental compliance, primarily through application of the "polluter pays" principle. This may ensure that for any given level of environmental quality desired, the society-wide costs of meeting the standard are minimised. However, in some cases, use of economic instruments may require

intensive monitoring, which too may entail significant social costs. On the other hand, use of existing policy instruments, such as the fiscal regime, may significantly reduce or eliminate the need for enhanced institutional capacities to administer the incentive-based instruments. In future, accordingly, a judicious mix of incentives-based and fiats-based regulatory instruments should be considered for each specific regulatory situation.

Compared to regulation, market-based instruments allow greater flexibility in the choice of means to reduce environmental damage. By doing so, they can be more cost-effective. The economic instruments can also make the costs of environmental protection more transparent and encourage greater innovation in more environment-friendly technologies.

Most economists favour the use of economic or market-based instruments, particularly emission taxes, over other instruments, especially control and regulation. This is mainly because of: (i) lower cost of compliance and higher economic efficiency; (ii) freedom to private enterprises to decide whether they pay taxes or invest in cleaner production technology; (iii) bureaucratic interference is minimum; (iv) incentives to innovate and to improve environmental performance over time; and (v) pollution taxes could be an important source of revenue to the government.

However, use of market-based instruments, particularly pollution taxes, has several disadvantages. One, there could be political compulsions either not to tax the polluters, or impose low taxes, which do not cover the whole of the external costs. Two, it is very expensive to administer taxes. Three, in developing countries like India, there is a high tendency to evade taxes through unethical practices. And finally, fixing socially optimum tax rates is problematic in view of the difficulties in measurement of the extent of emissions, and their valuation.

4.5 *Technological Measures*

Technological measures could be used both as 'preventive measures' as well as 'curative measures'. Although most of the problems of environmental degradation are considered to be having no technical solutions as they are rooted in human behaviour and attitude towards environment, there are some problems which could be solved through technological measures. For example, pollution of water bodies and degradation of land due to excessive use of chemicals in agriculture could be mitigated through the use of organic/bio-manures, organic/bio-pesticides and adoption of organic farming and the problem of soil salinity and water-logging created by excessive irrigation could be resolved by the use of micro irrigation technologies such as sprinklers and drips and sub-surface drainage. Water use in paddy cultivation could be reduced by as much as 40 per cent if the crop is grown under anaerobic conditions (Johl, 2006, p.608). Similarly the problem of air pollution engendered by the increased use of fossil fuels could be solved through the use of renewable sources of energy such as animal power, solar energy,

hydropower, and biogas. But to motivate the farmer to adopt the new eco-friendly technologies, it is necessary for policy makers to ensure that the new eco-friendly technologies are financially superior to the old environment-depleting ones and that the farmer has access to the requisite credit facilities and technical information and guidance.

The watershed management approach has been found to be the most appropriate strategy for optimum and sustainable use of land, water and other resources in rainfed farming areas. There are many success stories including those of Sukhomajri, Ralegaon Siddhi, and PIDOW (Gulbarga), that document how the adoption of watershed approach led to overall development of the watershed and restoration of its natural capital in semi-arid areas of India (Singh, 1995). Small water harvesting structures such as check dams, percolation tanks, recharge tube wells, and underground dykes could be used for recharging depleting groundwater aquifers and preventing their degradation.

Afforestation of degraded lands seems to be the most cost-effective and environment-friendly alternative for their restoration. A review of twenty-one studies of the economics of afforestation undertaken in the last two decades, or so in India showed that wastelands afforestation projects in India were financially feasible even if the non-market benefits of afforestation projects such as reduction in soil erosion, increased recharge of groundwater aquifers, carbon sequestration, moderation of micro climate, and improvement in the micro environment were not taken into consideration (Balooni and Singh, 2003). Further, it was also found that the financial internal rate of return (FIRR) from the afforestation projects was more than the prevailing interest rate on the long-term loans for forestry projects in India. This means that afforestation projects are financially viable and bankable, besides being eco-friendly. Besides, now that there are markets such as Chicago Climate Exchange (CCX), European Union Emission Trading Scheme (EU ETS) and United Kingdom's ETS, for buying and selling carbon credits, afforestation of wastelands, being an important source of carbon sequestration, could generate a lot of revenue mostly in the form of foreign exchange through the sale of carbon credits. However, to take advantage of carbon markets, we need to set up institutional mechanisms for certification of plantations by agencies accredited by globally recognised agencies.

4.6 *Education*

This instrument seeks to change the perceptions and priorities of users of environmental resources and services by internalising environmental awareness and responsibility into individual decision making. Besides education and persuasion, this instrument could also take the form of provision of information and training as well as forms of 'moral suasion' such as social pressure and negotiation. They can complement the economic and regulatory instruments and assist in their successful implementation. Education belongs to the category of 'preventive measures'.

Most scholars and practitioners in environment management recognise the need for education as an instrument for averting 'the tragedy of the commons'. Most users of environmental resources and services in both developed and developing countries of the world do not use them as they 'should', partly because they are ignorant about the nature and causes of environmental problems and partly because of many economic and institutional factors such as poverty, inappropriate structure of property rights and tenure. This stands in the way of their adopting socially-desirable behaviour. In the short run, education seems to be the logical and simple solution to the extent that environmental problems arise out of ignorance. Education should therefore be used as a means of alleviating ignorance.

4.7 *Enlisting Stakeholders' Participation*

Stakeholders' participation could serve as a 'preventive measure' if it is enlisted prior to implementing an environmentally harmful decision. Viable and sustainable conservation of the environment requires the participation of multiple stakeholders', particularly local people's participation in planning, implementation, and monitoring of environmental projects. Stakeholders may bring to bear their resources, competencies, and perspectives so that the outcomes of partnerships are eco-friendly and are superior to those of each acting alone. For this to happen, it is essential that all major stakeholders are organised into some form of formal or non-formal homogeneous groups, conscientised about the need for environmental protection and conservation, empowered through education and training, and motivated and guided preferably by local non-governmental organisations (NGOs). There are many factors that affect people's participation in collective action of the type required for environmental protection and conservation. But the most important among them is that the expected private benefits from participation must markedly exceed the expected private costs and that the expected benefits must be assured and equitably distributed among participants in proportion to contribution in the form of labour, cash or both. Singh (1991) identify the various factors that affect people's participation in natural resource management. They include project design, characteristics of the resource, characteristics of local people, type and orientation of project personnel, and institutional arrangements and incentives for people's participation.

In seeking to realise the partnerships among the diverse stakeholders, it is essential on the part of the government agencies involved to eschew the confrontational posturing adopted in many cases in the past. While it is not possible that the interests and perceptions of all stakeholders will converge in each case, nevertheless, it is necessary to realise that progress will be seriously impeded if the motives of other partners are called into question during public discourse. It is also essential that all partnerships are realised through, and are carried out in terms of the principles of good governance, in particular, transparency, accountability, cost effectiveness, and efficiency.

The NEP-2006 identifies a number of specific forms of for partnerships, a few of which are stated below (Government of India, 2006):

(i) Public -Community Partnership: This is intended to seek the co-operation of public agencies and local communities in the management of a given environmental resource, each partner bringing the agreed resources, assuming specified responsibilities, and with defined entitlements. The Joint Forest Management programme is an example of this kind of partnership.

(ii) Public-Private Partnerships: In this arrangement, specified public functions with respect to environment management are contracted out competitively to private providers, e.g., monitoring of environment quality.

(iii) Public -Community-Private Partnerships: In this system, the partners assume joint responsibility for a particular environmental function, with defined obligations and entitlements for each, with competitive selection of the private sector partner, e.g., afforestation of degraded forests.

(iv) Public-Voluntary Organisation Partnerships: This is similar to public -private partnerships, in respect of functions in which voluntary organisations may have a comparative advantage over others, the voluntary organisations, in turn, being selected competitively, e.g., raising environmental awareness.

(v) Public-Private-Voluntary Organisation Partnerships: In this arrangement, the provision of specified public services is accomplished on competitive basis by the private sector, and the provision is monitored by competitively selected voluntary organisations, e.g., "Build, Own, Operate" sewage and effluent treatment plants.

V

CONCLUDING REMARKS

Most of the natural resources including environment in India are in a serious state of degradation due to a variety of reasons, some of which are natural and some man-made. Examples of environmental degradation include soil erosion, water-logging, salinity and general loss of fertility of agricultural lands, making them less productive, pollution of surface water sources and degradation and depletion of groundwater basins, making water for drinking and irrigation increasingly scarce and unfit for use, falling fishery yields, and deteriorating air quality. Increasing levels of air, water and land pollution pose a serious threat to human health and longevity. Judicious management of natural resources and environment is essential not only for our survival but also for attaining and sustaining economic growth and development.

The measures that could be used for mitigating the problems of environmental degradation could broadly be classified into four categories, namely, institutional changes, direct controls, and economic/market-based instruments, and technological measures. When identifying the alternatives for mitigating the problems of environmental degradation, we should aim at minimising it, or at least restricting it to a level consistent with the society's objectives, rather than trying to prevent or eliminate it altogether. A simple rule of thumb for choosing a particular measure is that its estimated social benefits must markedly exceed its estimated social costs.

To sum up, we could say that we now have the requisite knowledge of tools, techniques and instruments of environment management available in India and we also have a National Environment Policy in vogue. What we need is a strong political will at the national and state levels and a congenial political and economic environment to use appropriate measures to mitigate the problems of environmental degradation in the large interest of society as a whole.

NOTES

1. According to a Green Media report dated January 25, 2006, over three lakh *sadhus*, who had assembled in Allahabad for Magh Mela which started on January 14, 2006, had launched an agitation complaining against the high-level of pollution in the river Ganga in Allahabad, and demanding government intervention to prevent the pollution and keep the Ganga waters clean.

2. India is one of the most flood-prone countries in the world and accounts for one-fifth of the global death count due to floods. Over 30 million people are displaced annually due to the floods.

3. In 2004-05, the value of fish and fish products exported from India was Rs. 6,188 crore (http://indiabudget.nic.in).

4. See for details see Singh and Shishodia (2007, pp. 194-95).

5. For details of economic instruments, see Singh and Shishodia (2007, pp. 181-192).

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