R. G. Mythili

Significance of the Problem

Agricultural production has witnessed dramatic rise in the last 3 decades or so in the countries world over. In India, Green Revolution brought about technological breakthrough, which led to the use of short duration high yielding varieties helping intensive use of land in a year, increasing area brought under irrigation and prolific use of chemicals such as fertilizers and pesticides. India, being vastly agriculture oriented, historically has had policies in various phases for the development of agriculture with the expectation that development of agriculture would lead to overall development of the nation and help eradication of poverty. It has been of late recognized that the increasing efforts to raise agricultural growth has cost us dearly in the form of land and water degradation. Large scale ecological losses were reported in crop land, grass land and forest land, such as soil erosion, soil alkalinity and salinity, micronutrient deficiency, water logging and fast depletion and contamination of ground water. These factors limit future gains from the land and water resources. The specific crops grown and the cropping practices employed also determine the residuals generated by the erosion and run-off. Irrigation is considered as the principle means of water loss from the natural system and it leads to arid condition downstream and ground water depletion. Apart from on site costs reflected in the loss of productivity of soil, the off site costs due to agriculture is reported to be quite significant. The off site costs are caused by soil sediments transported in the surface water from eroded agricultural land. These include, river and dam siltation, damage to roadways and sewers, siltation of harbours and channels, loss of reservoir storage, disruption of stream ecology and damage to public health. In addition, by raising stream beds and burying streamside wetlands, sediment can increase the frequency of flooding.

Intensive farming practices, particularly with wheat and rice in India, have virtually mined nutrients from the soil . Due to heavy use of fertilizers, excess nitrates have leached into groundwater and contamination of groundwater with nitrates has increased dramatically. As such, the cultivable lands have become sick by over-application of chemicals. Apart from over use of chemicals, equally important issue is imbalance in the application of fertilizers and pesticides.

Intensive agriculture has also led to extension of area under irrigation. In India, area irrigated has doubled over four decades, from 19% to 38% of the net sown area. Much of this increase has come from water extracted from the fast depleting ground water resources. Improper use and maintenance of canal irrigation has contributed significantly to the soil degradation problem. Extension of canal irrigation to arid and semi arid areas has resulted in water logging and salination.

According to the National Remote Sensing Agency and Forest Survey of India, 60% of the total area under cultivation is substantially degraded. Most of this damage is in the form of loss of topsoil.

It is true though that the 'underlying causes of degradation' has been very often the basic socio-economic structure and institutional structures of developing economies. Among them are land shortage, inappropriate land tenure arrangements, poverty, and population growth. However, the diverse factors that contribute to the problem make it necessary that a comprehensive approach is taken by the authorities responsible for policy in different areas such as food security, forests, soil conservation, and water resources.

Land Degradation as a result of Externality

The theoretical studies highlight the fact that the soil erosion is a result of rational farm decision making (Mc Connell, 1983). A rational producer, maximizing the discounted net revenue from land over time would not respond to soil loss until the present value of marginal private returns obtained from additional soil loss goes below the implicit marginal private cost of soil loss. The net value from land consists of two components; the present value of the revenue stream and the present value of the terminal value of the land. Soil erosion, not only affects future productivity but also the terminal value (Miranowski, 1984). The presence of large external cost (off-site costs) is neglected in the private decision. The rationale for policy intervention arise in two contexts (i) where off-site costs costs are significant (ii) where the on-site land degradation effect is not transparent to the owner. Various types of market failures in the land market have also been noted. Notable among them are common resource problem, tenurial arrangements, absence of risk market.

Prevention and Restoration Methods

While soil erosion is an important issue in dry land, salt affected soil and water logging are the major problems of irrigated lands. This causes increasing decline in productivity over the years and finally lead to land abandonment. Problems are aggravating further with more and more new lands being brought under canal irrigation without managing properly the existing lands. On irrigated lands logging problem has to be tackled by better drainage facilities.

Salinity and alkalinity problems are much more aggravated in areas where more than one source of flow irrigation exists, low precipitation, unscientific use of water, improper cropping pattern and drainage facilities. When water use is excessive, the underground water table rises and brings with it dissolved salts from substrata. If the water evaporates and leaves salts caked on the surface , it finally makes the soil useless agronomically. Salts with poor internal drainage facilities are mainly responsible for accumulation of salt in the root zone. There are number of studies that provide estimates of loss in productivity due to salinity and water logging. Reclamation is done through gypsum application continuously for three years with reduced application in the second and third years While those areas which are already affected require reclamation, preventing further soil erosion is a major task at hand. Integrated Water Shed Management is a major preventive method, which involves soil and water conservation efforts integrated with suitable cropping pattern . It involves constructions such as check dams along the gullies, bench terracing, contour bunding, land leveling and planting of grasses along contours etc. This will increase percolation of water into the subsoil system, reduce surface run off, reduce soil erosion and improve the water availability. Controlling of soil erosion involves maintaining a good vegetal cover on the watershed to prevent sedimentation. Sedimentation can be controlled either by controlling soil erosion or by handling of sediments at the deposits site. But the latter is not only expensive but also a very difficult process.

Land degradation monitoring is needed to formulate conservation strategies for the sustainable use of land resources. For identification of potential area for reclamation and land degradation monitoring, Satellite Remote Sensing is found to be a very useful and popular technical tool supplemented by others tools like Geographical Information System (GIS) and Global Positioning System (GPS).

Measurement Problem

It is always a difficult task to measure and value the loss due to degradation. Estimating soil loss is particularly difficult, because there are so many variables, some occurring naturally, such as soil and rainfall. As a result, models, whether empirical or process-based, are complex if they are to include the effects of all variables. For some purposes, meaningful and useful estimates can be obtained from models, and the best example is the estimation of long-term average annual soil loss from arable land, using the Universal Soil Loss Equation (USLE) or Revised Universal Soil Loss Equation (RUSLE) . RUSLE is an attempt to improve the capability of USLE in using dynamic hydrological and erosional processes and the flexibility of USLE in adjusting process parameters to account for spatial and temporal changes. Soil erodability factor method is also one approach to make accurate soil loss prediction. In recent years, there has been a proliferation of mathematical simulation models, based on the various physical processes involved in soil detachment, transportation and deposition.

Estimation of soil erosion has been done for India through some information on soil loss from runoff plots, watersheds and reservoirs . A systematic attempt was made by Singh et al (1992) by preparing a country wide map of soil erosion rate. They used the available maps of soil, rainfall erosivity, slope, land use, forest vegetation degraded lands, sand dunes and irrigation. Using this map, they have prepared iso-erosion rate map. The map has been used to estimate the erosion rates for various regions of India.

The extent of salinisation is more difficult to measure than simple soil erosion because the effect of saline soil is underground initially. Further excess quantities of waste also cause a building of soluble salts in the soil. Salts accumulate in the soil when the amounts added in wastes exceed the amounts removed by plant growth, leaching and other means. Eventually, a saline or a saline sodic soil is developed. The worst situation occurs when leaching removes the excess salts but leaves enough sodium to form a sodic soil. There are several sources of error associated with trying to correlate the amount of sediment measured in streams with the extent of erosion in the catchment. Measuring the total amount of sediment deposited in ponds or reservoirs avoids the issue of the sediment delivery ratio, but unless the reservoir is large enough to contain the whole of the runoff, some of the sediment will be carried over the spillway. Models designed for the prediction of soil loss are often concerned primarily with the loss of soil from agricultural land, and rarely extended to estimate sediment movement in catchments.

Valuation Methods

Loss in the value of soil due to land degradation such as erosion or change in soil quality must be valued in order to understand the environmental cost of agriculture. In the literature, soil loss has been valued using productivity approach, preventive cost approach, and replacement cost approach. The productivity approach basically attempts to value through impacts, viz. estimate soil loss through productivity loss. Preventive measures are factors such as conservation and defensive expenditure. The replacement cost is cost of restoration of soil to its original state.

Using experimental data Repetto et al.(1987) has valued soil loss through productivity loss. Econometrics techniques have been utilized in a few other studies (eg. Parikh, 1989; Parikh and Ghosh,1991) to estimate soil loss by writing yield function as separable in input response function and soil quality multiplier function. Given a measurable soil quality multiplier, one can find potential yield value foregone as a result of decline in soil quality for a given input bundle. The concept that farmers adapt their cropping pattern and inputs to alteration in the soil quality can be introduced in the model. Few studies estimate benefits from soil conservation through watershed development program in terms of productivity gains (e.g Ninan, 2002). This can be treated as the value of soil loss by preventive method. Few statistics are also available in a piecemeal manner on costs of reclamation.

Current Status

A recent pioneering study sponsored by three United Nations agencies (FAO, UNDP and UNEP) estimated the severity and costs of land degradation in South Asia. Its finding was that the countries (India, Pakistan, Bangladesh, Iran, Afghanistan, Nepal, Sri Lanka, Bhutan) are losing at least US$10 billion annually as a result of losses resulting from land degradation. This was equivalent to 2% of the region's Gross Domestic Product, or 7% of the value of its agricultural output. Yet this figure is still an underestimate, because it measures only the on-site effects leaving out off-site costs. The interesting part of the study is its assessment of the economic costs of land degradation. Total on-site annual losses were estimated at US$9.8 to 11 billion a year. The breakdown according to types of land degradation was: water erosion US$5.4 billion; wind erosion US$1.8 billion; fertility decline US$0.6 to 1.2 billion; water logging US$0.5 billion and salinisation US$1.5 billion.

All India Soil and Land Use Survey under the Department of Agriculture and Co-operation initiated land degradation mapping during the eighth five year plan allowing for the development of district information system for degraded lands. It has so far covered 30 districts located in diversified agro-climatic zones. It has also developed soil information system. Department of Land Resources, Ministry of Rural Development, Government of India has identified different types of degraded wastelands (Table 1). They prepared Wasteland Atlas of India for the year 2000, with the help of Indian Remote Sensing Satellites. This provides information on districtwise wasteland. These maps help identifying the potential lands for reclamation in the country. Various categories and their percentages to total geographical area for the country is depicted in the table below.

Table 1 Category wise percentage of degraded land as on 2000 as percentage of total degraded land

Gullied & or ravinous Land 3.22	3.22
Upland with or without Scrub 30.40	30.40
Water Logged & marshy Land 2.58	2.58
Land affected by Salinity/Alkalinity-Coastal/Inland 3.22	3.22
Shifting Cultivation Area 5.50	5.50
Under Utilized Degraded Notified Forest Land 22.02	22.02
Degraded Pastures/ Grazing Land 4.07	4.07
Degraded Land Under Plantation Crops 0.90	0.90
Sands-Inland/Coastal	7.84
ining Industrial Wastelands	0.20
arren Rocky/Stony Waste/Sheet Rocky Area	0.12
teep Slopping Area	1.20
now covered and or glacial Area	8.73

Note: Total wasteland as a percentage of geographical area is 20.16 Source: 1:50000 scale wasteland maps prepared from Landsat (from Wasteland Atlas).

It is very clear from the above statistics that the land with or without scrub category, which is mainly land affected by soil erosion, records the highest percentage followed by degraded and underutilized forest land. Needless to say, soil erosion is the major problem of land degradation. This was supported by other estimates available for earlier years on soil degradation in India from different sources (Table 2) .

However there are no reliable information available on type, intensity and severity of land degradation for India. Some estimates on productivity loss due to soil erosion are also available through Bansil and FAO cited in the study by Brandon et al. (1995). As per this, the total annual loss in productivity of major crops due to soil erosion is estimated as 7.2 million tones.

Table 2 Soil Degradation Statistics (area in million ha)

Type	Ministry of Agri. & co-operation		Sehgal and Abro	
	1980	1985	1994$	1997@
Soil erosion*	150.0	141.2	162.4	167.0
Saline and Alkaline soil	8.0	9.4	10.1	11.0
waterlogging	6.0	8.5	11.6	13.0
Shifting cultivation	4.4	4.9		9.0
Total degradation	168.4	175.1	175.0	187.8

** This includes both wind and water erosion , but water erosion accounts for more than 90%.*
$ Sehgal and Abrol (1994) @ TERI Report

A rough estimate of soil erosion and sedimentation for India reveals that about 5300 million tonnes of top soil are eroded annually and 24% of this quantity is carried by rivers as sediments and deposited in the sea, and nearly 10% is deposited in reservoirs reducing their storage capacity by 2%.
As for water logging and salination, the available estimates show that canal command area constitutes 48% of the total water logged area, and 45% of the total salt affected area in India. In fact for a few states like Andhra Pradesh, Tamil Nadu, Orissa, Punjab and Gujarat, canal irrigated area occupies 100% of the total water logged area.

The Soil and Water Conservation Division in the Ministry of Agriculture has taken initiative in the implementation of integrated watershed management programs. These programs are planned to cover 86 million hectares, of which 26 million hectares (27 river valley catchments and 8 in flood-prone rivers) in highly critical areas have been assigned priority under 35 centrally sponsored projects. In addition, over 30,000 hectares of shifting and semi-stable sand dunes have been treated with shelter belts and strip cropping as a conservation measure (TERI Report, 1997).

In 1985, National Land Use and Wasteland Development Council was constituted, former in the Ministry of Agriculture and the latter in the Ministry of environment and Forest. The objective was to formulate a National Policy and Perspective Plan for conservation and management of land resources, appropriate land use given the soil capability. Some reclamation work was carried out as part of wasteland development task. Annexure I gives more details on policies and programs related to land use and conservation in India,

Policy Suggestions

Land degradation problem could be tackled to an extent by suitable policies that internalize degradation in to producer decision making wherever possible. Rather wrong policy choices in the Indian context have aggravated the problems; to mention a few, zero or subsidized pricing of electricity for tubewell irrigation, heavily subsidized surface water for irrigation and subsidized chemical inputs. For example, overuse of poor quality tubewell water has led to soil salinity. Economic instruments in the form of incentives will be a cost effective measure to encourage farmers to adopt soil conservation practices. For problems regarding over application of chemical inputs, in the long run, conjunctive use of chemical inputs with bio inputs along with farm residues is the only answer.

At the macro level, the existing data base on land use statistics cannot facilitate analysis of land degradation and its impact. Adequate changes in the classification of Land Use Statistics are needed in order to study environmental impact of land use. Advanced technology like Remote Sensing can go a long way in helping generation of more information on different dimensions of land degradation.

The information base on which farmers make decisions is incomplete with respect to internalizing rapid changes in soil and water quality variables by moving to more sustainable practices such as integrated pest management, more land conservative crop rotations. Research has to focus more on sustainable practices such as integrated crop management. An integrated approach to the problem of degradation linking agriculture and environment is yet to be attempted even though at the policy level, it has been stressed.

The existing land use policy failed to bring right results due to lack of integrated approach to different components of agriculture such as land, soil and water. While legislations to protect resources such as forest Conservation Act, Biodiversity Bill have been passed, no such legislation exists exclusively for soil related problems. Soil Conservation in arid, semi arid and dry sub-humid areas had been included as one of the themes in the international convention on 'Combating desertification' in 1996. India participated and ratified its commitments. The objective was to curtail the wide scale deforestation and water shed degradation through appropriate measures. In India, The Soil Conservation Programs have been mostly confined with Agriculture Departments, and the aim was to educate the farmers with various conservation practices. But so far the programs did not meet with success due to the absence of participatory approach. While more attention has been paid to issues such as forest land conversion to agriculture, which is related to extensive cultivation, not much focus has been given to degradation due to intensive cultivation practices of the existing land. Recently MoEF has initiated efforts to address this issue. Often action on these issues conflicts with agriculture development in the short run.

Farm research should address on balancing of external inputs use and internal sources of nutrients. Thus from a policy perspective, there is a need for public and private initiative on several fronts-increased investment in resource management, research and extension, research to develop suitable and more sustainable cropping patterns and rotations, correction of price distortions on key inputs, especially water and electricity, and special incentives to invest in bio inputs and also inputs like gypsum that helps reclamation of salt affected soil. Such policy interventions may be rewarding if they can counteract the environmentally perverse land use. However, costs of such interventions have to be considered against potential benefits, before making definite policy prescriptions.

Annexure I

Policies /Programs that have a Bearing on Land Resource Use

Year	Programs/Policies	Specific Features
1977-78	Desert Development Program	• Restoration of ecological balance by harnessing, conserving and developing natural resources

1985	National Land Use and Wasteland Development Council	• Policy planning concerning the scientific management of the country's land resources • development of wasteland
1985	National Land Use and Conservation Board	• Review of Progress of implementation of ongoing schemes and programs connected with conservation and development of land resources and soils • Formulate a national policy and perspective plan for conservation, management and development of land resources of the country
1985	National Wastelands Development Board	• Formulate a perspective plan for the management and development of wastelands in the country • identify the waste land and assess the progress of programs and schemes for the development of wasteland • create a reliable data base and documentation centre .for waste land development

1988	National Land Use Policy	• To devise an effective administrative procedures for regulating land use • to prevent further deterioration of land resources • restore the productivity of degraded lands§ allocate land for different uses based on land capability , productivity and goals
1989-90	Integrated Wastelands Development Project	• adopt soil and moisture conservation measures such as terracing, bunding etc… • enhance people's participation in wasteland development programs
1992	Constitution(74th Amendment) Act, 1992	Regulation of land use and urban planning brought under the domain of urban self-governing bodies
1999	Department of Land Resources	• Formulation of Integrated Land Resource Management Policies • Implementation of land based development programs

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