

3.1.1 INTRODUCTION

Land is the basic natural resource that provides habitat and sustenance for living organisms, as well as being a major focus of economic activities. Degradation of land refers to loss of its potential production capability as a result of degradation of soil quality and also its loss for effective use. In Bangladesh, the topsoil degrades due to natural processes and human activities. The functional capabilities of soil deteriorate from activities related to agriculture, forestry, and industry. On the other hand, urban sprawling and infrastructure development cause loss of available land. Natural events such as cyclones and floods cause land loss, and can also deteriorate functional capabilities of soil. Soil degradation in the coastal area results from unplanned land use, as well as intrusion of saline water. Therefore, solving or minimizing land degradation problems should be based on multi-sectored, multi-layered, yet integrated approaches.

The land degradation section of this report deals with causes of land degradation, both in terms of deterioration of soil quality and loss of land. It also highlights state and impacts of degradation, along with policy and program responses.

There are several issues related to land degradation that intersect with other concerns. The most relevant of these have been addressed in other chapters of the report. For example, land related environmental problems, particularly droughts and floods, have been discussed under the Natural Disaster section. The Biodiversity section addresses issues of shrinking wetland in the dry season. The Water Pollution and Scarcity section deals with lean water flow in the river system and fluctuation of groundwater.

3.1.2 PRESSURES

There are many driving forces compelling people in Bangladesh to over-exploit natural resources like land. The main ones are the poverty with rapid population growth, improper land use, absence of a land use policy, and ineffective implementation of existing laws and guidelines. Unplanned agricultural practices, and encroachment on forest areas for agriculture and settlements, also put pressure on scarce land resources. Unplanned or inadequate rural infrastructure development and the growing demands of increasing urbanization are also devouring productive land. The level of land

degradation and its extent vary seasonally and yearly, by region, as well as the pressures on land are not always the same either.

Natural processes that lead to land degradation in Bangladesh can be considered part of the ongoing land formation process. The upliftment and deposition processes that led particularly to formation of land in the regions of Sylhet, Chittagong, Barind and Madhupur continued during the period of the Miocene, Pliocene and Pleistocene ages. Throughout the Pleistocene time up to the present, the rivers have been depositing heavy sediments to build up the country's flat alluvial plain, although the processes of erosion and deposition have not been similar all along. There are a few studies on recent sedimentation and erosion that show these processes have been aggravated by human interventions such as encroachment for settlement and improper agricultural practices.

Land degradations caused by nature are often balanced by formations of new land. Deterioration of soil quality and land loss due to human intervention may not always be reversible.

If the pressures on land are considered in a region-wise manner, the following picture emerges:

Land degradation in the Chittagong Hill Tracts (CHT) is occurring mainly due to rapid changes in demographic patterns, development of roadways and other physical infrastructure. *Jhum* cultivation, the traditional community-based agricultural method practiced by the indigenous people of the CHT, is one of the major causes of land degradation. Degradation of land in the hilly area has also occurred due to the mobilization of defense regiment for peace keeping in the CHT, which leads to destruction of forestland and loss of land cover.

The Madhupur forest area has almost been denuded due to deforestation and has further been aggravated by many other factors such as its closeness to the capital city, improvement of road communication leading to displacement of population, urbanization and industrialization. This land, a Pleistocene terrace, is naturally raised and flood-free, therefore, it is attractive for infrastructural development. The land in the area has further been degraded by the development activities related to building of the Jamuna Multipurpose Bridge.

Land degradation in the Barind Tract is caused mainly due to over exploitation of biomass from agricultural

lands and unscientific cultivation of HYV rice through groundwater irrigation. The process has been aggravated by irregular rainfall; and insignificant water flow in the adjacent rivers that normally play a vital role in replenishing soil fertility and recharging groundwater.

Degradation of soil quality in the floodplains is mainly attributed to improper use of chemical fertilizers and pesticides to boost agricultural production. Siltation in the floodplains also contributes towards degradation of land due to flashflood and sediments accumulated from riverbank erosion. Dispersed industrial growth and uncontrolled discharges of their untreated effluent in the nearby rivers deteriorate the quality of land and soil.

Land degradation in the coastal areas of Bangladesh is a result of recurring cyclones and storm surges, which inundate the land. Practice of shrimp cultivation round the year is ultimately increasing

the salinity of the degraded soil. Intrusion of saline water in the dry season is attributed to the low flow in the river system.

Human interference and waterborne action are the two most important land degradation processes in Bangladesh. Table 3.1.1 presents driving forces and pressures, state, impacts related to land degradation and responses to address the problems.

3.1.2.1 Human Activities

Improper Cultivation in Hill Slopes, Terrace Land and Piedmont Plains

Shifting cultivation on the hills, locally known as “*Jhum*”, is a common practice among the tribal communities in the greater Chittagong Hill Tracts. Traditionally *Jhum* cultivation is a slash-and-burn process where a certain area is cleared and cultivated

Table 3.1.1 Pressures, State, Impacts and Responses of Land Degradation

Driving Forces & Pressures	State	Impacts	Responses
• Population and Poverty	• Increasing population	• Depletion of natural resource base	• Population control and poverty alleviation program. [E]
• Improper agricultural practices	• Unscientific use of agricultural inputs (chemical fertilizer and pesticides)	• Yield reduction due to quality degradation of soil and thus decreasing land productivity	• Integrated Plant Nutrient System (IPNS) • Integrated Pest Management (IPM). [E] • Induction of green manuring crop, biomass recycling. [E]
• Agriculture practices in hill, terrace and piedmont area	• Deforested area	• Loss of topsoil • Gradual siltation in the floodplain and water bodies	• Occasional restriction and ban of <i>Jhum</i> cultivation [E] • Massive afforestation [E] • Adoption of SALT (Sloping Agricultural Land Technology)
• Improper irrigation	• Declining soil nutrient	• Yield reduction due to quality degradation of topsoil	• Irrigated Agricultural Development Strategies [E] • Use of surface water for irrigation [E]
• Development of rural road network	• Increased length of road	• Loss of productive agricultural land	• Draft Land Use Policy [P] • Integrated road, embankment and drainage system
• Mining of sand and gravel	• Abandoned area is increasing	• Loss of productive land	• Draft Land Use Policy [P]
• Land ownership and tenure	• Land fragmentation	• Quality degradation	• Draft Land Use Policy [P]
• Riverbank erosion and sedimentation	• Erosion and accretion of land	• Loss of land and quality degradation	• Riverbank protection and embankment [E]
• Salinity	• Salinity intrusion	• Quality degradation	• Augmentation of dry season flow [E/P]
• Industrial pollution	• Open discharge to land	• Quality degradation	• Environment Protection Act and Rules (95/97) [E]
• Rural housing	• Horizontal expansion of	• Seizing of productive land	• Vertical expansion of rural housing [P]
• Urbanization	• Increased unplanned land use	• Loss of land	• Draft Land Use Policy [P]
• Brick making and kiln	• Number of brick kilns are increasing	• Loss of topsoil • Destruction of productive land	• Draft Land Use Policy [P] • Environment Protection Act and Rules (95/97) [E]

Source: SoE Study Team

Note: E stands for Existing and P stands for Proposed

for 1-2 years, and then abandoned for 5-12 years until the natural fertility of the soil is regained to a useful economic level (Rahman, 1991). In the recent years this traditional agricultural practice is considered as the most inefficient way of using the rich forest lands. Due to increase in the number of population in the CHT region there is a demand on agricultural production, which is putting pressure on cultivable land. As a result, the traditional regeneration time is not being allowed, and the soil is losing its fertility.



A view of hill slope agriculture

Clearing of natural vegetation for cultivation of pineapple, ginger and turmeric along the slopes has an ill effect, which increases soil erosion in the Sylhet and in the hilly areas of Chittagong. These lands after 5-7 years of cultivation by this method totally degrade to an almost irreversible state, to the extent that it becomes practically unfit for further generations. Rubber plantations on more than 70 per cent of the slopes of Sylhet and Chittagong hills, leads to severe landslides during the heavy monsoon period.

The population pressure and scarcity of agricultural land has caused a heavy influx of settlers from the plainlands to the unprotected forestlands of Madhupur and Barind tracts and also to the northern piedmont plains. The topsoil of all these areas is either laid over infertile loamy soils of shallow depth or over heavy compact clays. Clearing of forestland for settlements and unscientific land management for agricultural use accelerate erosion of the topsoil with the runoff from high monsoon rain. In addition, the infertile heavy compact clay is exposed to the surface as a result of the removal of topsoil.

Faulty Irrigation

The availability of irrigation water can be a blessing or a curse depending upon how it is

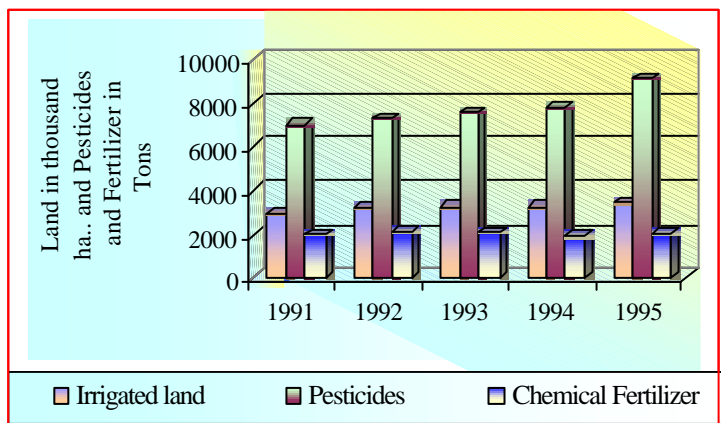
used. During the Fourth Five Year Plan (FFYP, 1990-94) a tremendous increase was made in the installation of Shallow Tubewells (STWs) and Deep Tubewells (DTWs) for groundwater irrigation. Most of this irrigation water is being used on relatively impermeable highlands of piedmont plain, meander floodplain and in terrace areas. A very small area is being irrigated in the *haor* basins by this irrigation system. In the highlands, the cropping pattern is mostly transplanted HYV *Boro/Aus* followed by rain-fed transplanted *Aman*, but in the basins broadcast *Aman* is grown followed the HYV *Boro/Aus* varieties. As a result of this irrigation, the land remains inundated in most of the seasons, which keeps an adverse effect on soils because of continued oxygen deprivation in the sub-soils. Chemical changes of soil material forming toxic compounds for plants and constant percolation loss of essential nutrient elements including micronutrients and organic matter.

Imbalanced Fertilizer Use

The use of chemical fertilizers is directly linked to farming in irrigated lands. Three types of fertilizers such as Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MP) and four types of pesticides are commonly use in Bangladesh, which are insecticides, herbicides, fungicides, and rodenticides.

Figure 3.1.1 presents trends of irrigated land and use of chemical fertilizers and pesticides from 1991 to 1995. In 1991, the use of nitrogenous fertilizer alone accounted for about 67 per cent of the total fertilizer use, which rose to 88 per cent in 1995. Although there was no significant increase of total chemical fertilizer application. However, significant increase has been

Figure 3.1.1 Trend of Irrigated Land, Pesticide and Fertilizer Use



Source: BBS, 1994 and 1998

observed in use of pesticides, which has serious implication to quality of land and ecosystem.

Ploughpan

Transplanted rice covers the widest cultivated areas of Bangladesh, and is grown on medium highlands and medium lowlands. The soils are puddled in a wet condition for easy transplantation and to prevent percolation loss, but this destroys the soil structure. As a result of ploughing in wet condition, a compact 3-5 cm ploughpan is formed from the pressure of the plough, as well as from the pressure during the transplantation of seedlings (Rahman, 1991). This ploughpan impedes soil drainage, restricts root penetration to deeper levels and the movement of soil moisture from subsoil to the topsoil during the dry season. The resultant loss of soil structure makes the topsoil water resistant and hard, which makes tillage difficult and often makes it unfit for cultivating *Rabi* crops. Some people argue that if this compacted ploughpan method is not used, transplantation of rice will be affected, but this has not been shown to be true except in the shallow valleys of Madhupur and Barind tract.

Improper Use of Pesticides

Farmers of Bangladesh are using pesticides since 1957 and at present on an average of 12-15 thousand tons of pesticides is used every year. Insecticide accounts for about 90 per cent of the total consumed pesticide, and is used most for cultivating vegetables and *Rabi* crops (BBS, 1984 and 1998). Although pesticides are used at low levels still they are a cause of land degradation. The pesticides sprayed over standing crops ultimately contaminate the surrounding soil. Research findings show that pesticides applied at the rate of about one kilogram per hectare contaminates the topsoil to a depth of about 30 cm. The pesticides not only destroy harmful insects, but also destroy useful topsoil microbes, which eventually reduce the biological nutrient replenishment of the soil.

Over Exploitation of Biomass from the Agricultural Fields

One of the most important causes of land degradation specifically in the Barind tract, is over exploitation of biomass from cultivated fields (Hunt, 1984). The acute energy crisis in various areas leads to all available vegetation being scavenged for firewood and fodder. Due to the reduction of

vegetative cover from this withdrawal of biomass silty loam topsoil over low permeability compact heavy clay is lost and topsoil gets inadequate water conservation capability. Therefore, there is considerable runoff due to heavy rainfall during the monsoon. This process of land degradation is also common in other highland and medium highland areas.

Unplanned Rural Infrastructure (Road, Embankment, FCD/I)

The rural roadways of the country have been constructed under *Upazila* or District programs through *Upazila* or *Union Parishads* (local level government). Therefore, the road alignment was subject to the influence of local politicians and influential people. A noteworthy feature of this alignment is that it follows the boundaries separating agricultural lands, rather than cutting through them. As a result, the actual length of the roads is often much longer than needed.

A significant part of the roadways constructed under the rural road network program fall within the floodplain, with a view to easy road communication during the monsoon season between village to village, villages to markets and villages to some industrial units. Therefore, the road heights had to be kept above flood level, for which a significant portion of agricultural land was acquired for the roadway and the borrow pits along the sides of the roads.

The main objectives of the development of flood control drainage and irrigation are to reduce flood hazard, facilitate agricultural productivity and the livelihood of rural households. The impacts of flood control, drainage and irrigation infrastructures have been given in detail in the Biodiversity section.

Urbanization

Urban development is necessary for economic growth, but the present process of urbanization in Bangladesh invariably reduces the amount of good agricultural land. Dhaka city has been growing at the expense of what were dense jackfruit and mango orchards in Savar, Gulshan, Banani and Uttara areas. The expansion of Khulna is reducing the coconut plantations of Phultala and Abhayanagar. These lands were not only good for horticulture, but also for *Aus*, *Transplanted Aman*, sugarcane and all kinds of dry land crops. The rapid urban growth of the past

two decades has mainly affected potentially triple croppable highlands.

Brickfields and Biomass Use

Brick making is a dry season activity that can be started as soon as the monsoon rain stops. Unfortunately, brick kilns are mostly situated on good agricultural land as brick manufacture needs silty clay loam to silty clay soils with good drainage conditions, which is turning good agricultural land into unproductive lands. Brick kilns are spread all over the country, and are degrading land. Moreover, over 50 per cent of the energy used for firing bricks comes from biomass.

Unplanned Industrial Development

Unplanned industrial development is of concern because it often encroaches on fertile land, and industrial effluents not only deteriorate the quality of soils but also affect fisheries. Despite the low level of industrialization, there are many pockets where effluent discharge cause serious harm to crops and fisheries. The rivers *Sitalakhya*, *Buriganga*, *Karnaphuli* and their banks are some of the many examples. There are areas of damage around or downstream of industrial units. Vast effluent discharge by ships has been identified as a major cause of pollution in the *Passur* river downstream of Mongla port. This has affected both forest and coastal lands in the Sunderbans (UNDP, 1989). The distribution of the most polluting industrial units and their subsequent impacts on water and land are given in detail in the Water Pollution and Scarcity section of the report.

In addition to polluting both water and land, most industrial units have acquired or bought more land than is required. This can be seen in all the district industrial estates, for example, on the other side of the *Sitalakhya* river along the Dhaka-Chittagong road. In Khulna, a big area has been acquired and part of it has been utilized for industrial units and part remains unutilized. Planned industrialization and land zoning would be appropriate measures to combat this type of land degradation.

Mining of Sand and Gravels from Agricultural Land

Mining of sand from agricultural land is common along the eastern side of the Dhaka-Chittagong road, from Comilla to near Sitakunda, and in the northern piedmont areas of northern Netrokona District. Farmers tend to enjoy the immediate

monetary benefit and lease out their land for extracting sand, which is used in glass manufacturing industries or as building material. First, 2-3 feet of topsoil are removed from the land and dumped anywhere available near the site. Sand is extracted to a greater depth. Once the sand is extracted, the new tenant abandons the site and no one is responsible for making the land productive again (Rahman, 1991). The damage is two fold - the land purchased for dumping topsoil is used unproductively, and the land from where sand is extracted remains unutilized for many years.

Extraction of pebbles from 2-3 feet below the surface of agricultural land is a common phenomenon in the northern part of greater Dinajpur and Rangpur Districts. There are many similar examples of wasteful use of land by businessmen. Farmers lease out or sell their land at higher prices for immediate gain, but in fact a portion of farmland is lost from their descendents, and eventually there is an environmental loss to the nation.

Land Ownership and Tenure

The present land tenure and commercial approaches do not provide security to farmers. Since Bangladesh is mostly an alluvial delta, there are land formations of different ages from very recent to old alluvium. Soil improvement for sustained crop production in new alluvial land is a long-term process. But the short-term leases that are common do not provide an incentive to farmers to engage in long-term land improvement.

There are many other such related problems. Big farmers cannot manage all their parcels of land by themselves. Therefore, in almost all cases owners retain the irrigable lands (even if they cannot manage them all themselves) and lease out the relatively less productive, non-irrigable land. The practice has two adverse effects on agricultural land. Firstly, the landlord's attitude that the land is less valuable has a negative effect psychologically on the sharecropper in terms of management of the land. Secondly, the sharecropper calculates his short-term benefit when farming the land, rather than thinking of the future for making the land more productive than its present state.

3.1.2.2 Waterborne Land Degradation

Riverbank Erosion and Sedimentation

The most devastating form of waterborne land degradation in Bangladesh is riverbank erosion. The

active floodplains of the *Ganges*, the *Brahmaputra-Jamuna*, the *Tista* and the *Meghna* rivers are most susceptible to riverbank erosion. Moreover, small rivers, particularly in eastern Bangladesh, also erode land, although to a relatively lesser extent than the big rivers.

There are many factors that may be responsible for riverbank erosion. The unique, natural geographic setting, the behavior of an alluvial channel, together with characteristics of the tropical monsoon climate, are mainly responsible for these ravages. An enormous volume of water comes from the melting of ice in the Himalayan range. Besides natural processes, human activities both up and downstream, mainly irrational use of forest and other natural resources, cause further deterioration of the situation (Islam, 1986). The whole combination of factors creates an ideal situation for producing devastating floods, which cause bank erosion and sedimentation.

In the southern part of the country, the riverbank erosions are also severe. Hatia, Sandwip and Bhola islands are severely prone to recurrent bank erosion. The amount of water and sediment carried in the *Ganges-Brahmaputra-Meghna* (GBM) river system is given in detail in the Water Pollution and Scarcity sections of the report.

Deposition of Sandy Over-wash on Agricultural Land

Deposition of sandy materials on agricultural land is frequent in the lower part of the piedmont areas of greater Mymensingh and valleys of Sylhet and Chittagong Hill Tracts. This is the net result of deforestation in the hills of the upper catchment areas. During the monsoon season, when heavy rainfall occurs in the upper hill areas, it causes flash floods in the lower plains. With the runoff, the water carries sandy sediments that spread over agricultural lands. In the areas of the lower foothills, deposits of sandy materials go up to even a few meters, which compels farmers to abandon such land for agriculture purposes.

Land degradation by deposition of sandy materials on agricultural land also occurs when there is a breach of embankments and the materials spread over adjoining agricultural land. This kind of local land degradation often occurs in many riverbank embankments, in the Flood Control and Drainage (FCD) and Flood Control Drainage and Irrigation

(FCDI) projects. Many of the Flood Control projects that could not be completed in time resulted in spillover from unfinished polders onto adjoining fields during the monsoon season.

Salinity

Land with saline soil occurs in the young *Meghna* estuary floodplain and in the southern part of the *Ganges* tidal floodplain. Salinity in the coastal areas developed due to continuous accumulation of salt from tidal flooding and salt removal by leaching or washing by rain or inadequate freshwater flushing. Salinity during the dry season mainly develops from the capillary rise of brackish groundwater to the surface. Total salt affected area of the coastal area is 0.83 million hectares, detail of which is given in Table 3.1.2.

Table 3.1.2 Soil salinity distribution from August to April

Month	Area under different soil salinity class (in thousand hectares)				
	S0	S1	S2	S3	S4
August	287.4	426.4	75.8	41.9	2.0
September	258.6	433.9	93.1	45.9	2.0
October	244.3	426.9	110.4	47.9	4.0
November	215.5	391.7	170.4	45.9	11.0
December	201.2	406.0	162.4	51.9	12.0
January	201.2	384.7	179.8	55.8	12.0
February	172.4	413.5	175.8	57.8	14.0
March	115.0	428.3	210.5	63.8	16.0
April	0.0	287.4	426.4	79.8	39.9

Source: Karim, 1990

It is reported that upstream withdrawal of the *Ganges* water has significantly reduced the freshwater discharge, and hence salinity is encroaching gradually deeper into the mainland. As a result, farmlands are being degraded by increased salinity, non-availability of groundwater for irrigation, industry and domestic need.

3.1.3 STATE OF LAND DEGRADATION

Comprehensive studies are lacking on the issue of land degradation in Bangladesh. The country needs further research and studies to precisely delimit the areas affected by, or vulnerable to land degradation. There are inadequate statistics on how much area is annually brought under shifting cultivation in the Chittagong Hill Tracts. Statistics on loss of forestlands in Madhupur, Barind and Piedmont

plains for agriculture, and other uses are also insufficient. There are few studies on the wastelands created by abandoned brick fields, and associated abandoned roads, but a good amount of land once regarded as good agricultural land has now turned unproductive. Statistics on irrigated area and uses of different pesticides are available, but studies on the extent of land degradation are lacking. The information is insufficient to make a comprehensive nationwide assessment on land degradation. However, a number of case studies are available, which do give an idea of the condition of land and the state of land degradation. A few of these examples are described below.

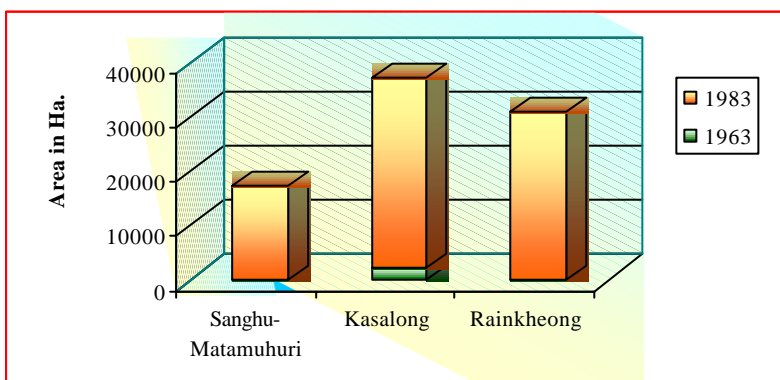
A few case studies have indicated that *Jhum* cultivation has been intensified, and has shown an increasing trend over the past few decades. Figure 3.1.2 shows the changing status of *Jhum* cultivation in three forest ranges. An evaluation of the Sanghu-Matamuhuri reserve forest indicated that shifting cultivation, which was practically non-existent in 1961, accounted for 17,135 ha in 1984, which is about 23 per cent of the total area. In Kasalong, 2,096 ha



A view of deforestation

Topsoil erosion per unit area depends on the type of land cover and land use practices. It was found that topsoil erosion rate is 2.7 to 7.2 tons per ha per annum in the mixed forest-covered land. On the other hand, per hectare erosion goes up to 120 tons in the deforested hill slopes (Shahid, 1994). A study in Khagrachari, Rangamati and Bandarban area on topsoil erosion revealed that topsoil erosion ranges from 100 to 120 tons per ha annually (Farid *et al.*, 1992).

Figure 3.1.2 Changes of *Jhum* Cultivated Area in Three Forest Ranges



Source: Rahman, 1991

were identified as *Jhum* areas in 1963, whereas in 1983 the area increased sharply to 35,079 ha. In Rainkheong, in 1963 *Jhum* area was only 14 ha, which increased to 30,838 ha in 1983 (Rahman, 1991).

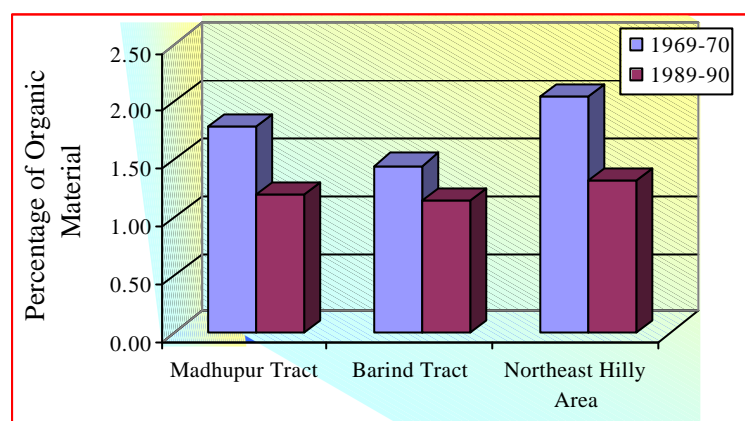
Landsat imagery indicates a definite change in vegetative cover and soil moisture in the Barind Tract, particularly the Western Barind. It resembles an arid zone during the months of March-April, although once moderately sized forest, bushes and shrubs were visible (Hunt, 1984).

Erosion of topsoil in the hill districts has increased, and 17 per cent of the soil resources have deteriorated between 1964 and 1985 (IUCN, 1991).

The amount of organic matter in the soil is one of the best indicators representing soil quality. The concentration of soil organic materials in the country has been deteriorating over the last few decades. Now over 50 per cent of the agricultural land is below the critical level. The highest deterioration of organic materials has been found in the Barind Tract, Madhupur Tract, Himalayan Foothill areas, the floodplains of *Tista*, *Karatoya* and *Bangali*, and in the northeast hilly region. Moderate deterioration of organic materials has been observed in medium highlands of the rivers *Tista*, the *Jamuna* and in the *Ganges* floodplain (Karim *et al.*, 1994). Figure 3.1.3 shows changes of organic materials from 1969-70 to 1989-90.

The Soil Resources Development Institute (SRDI) has analyzed soil samples, and found that nitrogen deficiency is common all over the country. The Sylhet *haor* areas, *Surma-Kushiyara* floodplain, northeast hilly area and Madhupur Tract have a noticeably intense deficiency of Phosphorus. Deficiency of other chemical substances has also been noticed in other parts of the country.

Figure 3.1.3 Changes in Organic Matters from 1969-70 to 1989-90



Source: Karim et. al., 1994

As shown in Table 3.1.3, the level of organic matter in the soil of Bangladesh is very low. About 45 per cent of the net cultivable area (NCA) of the country has less than 1 per cent organic matter content.

Accurate assessment of the salt affected area in the coastal region is very difficult, as the level of salinity varies according to season and year. However, it is clear from different sources that the salinity level of both surface water and soil has increased over the last decade. Saline affected areas in the coastal district have increased to about 3.05 million in 1995 from 0.83 million ha in 1966-75 (Karim et. al., 1990 and SRDI, 1997). Noteworthy changes occurred in the categories which lies above 8 dS/m. During the period of 1966-75, a very small amount of area was under the category of more than 8 dS/m, which became intense in 1995. Changes of saline affected areas are shown in Figure 3.1.4 in detail.

Studies on riverbank erosion have shown that the overall erosion is higher than sedimentation along the riverbanks in the *Brahmaputra-Jamuna* river system, and that there is net accretion in the *Meghna* estuary starting from Chandpur.

The “Riverbank Erosion Impact Study”, conducted jointly by Jahangirnagar University and University of Manitoba during 1984-87 at three places, namely, *Chilmari* (Rangpur), *Kazipur* (Serajgonj) and *Bhola*, found that about 15,750 ha of

land eroded over the period of 1961 to 1981, while only about 4,600 ha land have been formed through accretion (Elahi, 1985).

Environment and GIS Support Project for Water Sector Planning and Delft Hydraulics conducted a study on behalf of Water Resource Planning Organisation (WARPO) on “Morphological Dynamics of the *Brahmaputra-Jamuna* River” from 1973 to 1996, using remote sensing images. Their study showed a total of 73,552 ha of land eroded during the period of 1973 to 1996, while only 10,628 ha of land have been formed by accretion.

Analysis of remote sensing data for the period of 1993 to 1998 measured the net accretion in the *Meghna* estuary, starting from Chandpur towards the Bay of Bengal (MES, 1999). Up to 1984, erosion was higher than the accretion, but major accretion occurred during the period 1984-1990 and 1993-1996. The accretion and erosion over the years amounts to 107,863 and 87,967 ha, respectively. Thus the net accretion in the *Meghna* is about 19,896 ha. Figure 3.1.5 presents erosion and accretion in the *Brahmaputra-Jamuna* and *Meghna* river systems.

Based on currently available information and data, it appears that all agricultural lands have degraded to different extents. From this about 8 million ha show fertility decline and deficiency of nutrients,

Table 3.1.3 Organic Matter Status of Bangladesh Soils

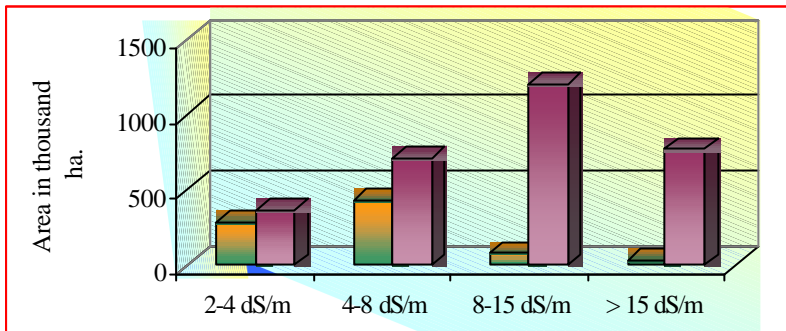
Class of organic matter	Main Locations	Total Area (Mha)	% of NCA
Very Low (<1.0 %)	Dinajpur, Sherpur, Jamalpur, Tangail, Nawabganj, Rahshahi, Pabna, Kushtia, Bogra, Naogaon, Rangpur, Khagrachari, Bandarban and Chittagong	4.05	44.5
Low (1.0-1.7 %)	Adjoining area of Tista, Dharlus, Chandpur, Lakshimpur, Noakhali, Bhola, Barisal, Patuakhali, Narsingdi and Dhaka	1.56	17.1
Medium (1.7-3.5 %)	Sirajganj, Mymensingh, Kishoreganj, Sherpur, Jamalpur, Sylhet, Moulvibazar, Feni and Cox’s Bazar	1.94	21.3
High (>3.5 %)	Panchagarh, Natore, Naogaon, Khulna, Satkhira, Madaripur, Gopalganj, Munshiganj, Habiganj, Sunamganj and Netrokina	1.56	17.1

Source: BARC, 1999

which has significant implication on production (Karim and Iqbal, 2000). Based on the agricultural suitability, different levels of degraded land have been categorized further as light, moderate and strong. The degraded terrain has reduced suitability for high yielding agricultural productivity, but is

urbanization. The most striking example is the Bangladesh Agricultural Development Corporation (BADC) agricultural estate at Kashimpur. The Kashimpur Agricultural Estate of BADC was established on very good agricultural land to meet the demand for vegetables in Dhaka city, but now it has effectively turned into urban land.

Figure 3.1.4 Salt Affected Area in 1966-75 and 1997 (average)



Source: Karim et. al., 1990 and SRDI, 1997

suitable for local farming systems. Restoration to full productivity is possible through modifications of management system. When original biotic functions are more or less largely intact and production loss is about 5-10 per cent, the degradation is termed light; for the moderate class the productivity loss is about 20-25 per cent, but it is still suitable for use in local farming systems; major improvements are required to restore productivity of the strongly degraded class, as the original biological functions are partially destroyed. Various types of land degradation are presented in Table 3.1.4.

During the last few years, thousands of kilometers of rural roads have been constructed under a “Food for Work Program”. Current data on the total length of roads constructed in each *Union* or *Upazila*, and how much land has been acquired for this purpose is not available. An inventory is in progress detailing the types and status of these roads by CARE Bangladesh and Local Government Engineering Department (LGED).

Data on the exact amount of agricultural and forest land transformed due to urbanization is scanty, but a few examples of this phenomenon are obvious. Most of the flood-free land to the north and west of Dhaka City is among the best horticultural land in the country, but has now gone under extensive of

As for another example, the acquisition of 300 ha of land for Rajshahi University, of which only 120 ha have been utilized so far, is a misuse or abuse of scarce land of that region. Again, acquisition of 40 ha of land in Faridpur for the River Research Institute was done at the time when there was already an alarming condition of land scarcity, perceived both by the Government, as well as the public.

There are many more examples scattered all over the country such as abandoned airstrips constructed originally for aerial plant protection services, *union* fertilizer storage sheds, etc. Large quantities of good farmland in almost every *upazila* are being used for construction of office buildings, shopping complexes, houses, schools, colleges, universities, hospitals and health centers, although there are alternative less agriculturally important lands available nearby.

3.1.4 IMPACTS OF LAND DEGRADATION

Land degradation is not merely a matter of physical loss of land or quality, but has inter-related impacts. For example, riverbank erosion is more than just a physical phenomenon of land degradation. For the poor, loss of crucial land resources affects them economically, socially, and psychologically. In

Figure 3.1.5 Erosion and Accretion in *Brahmaputra-Jamuna* and Lower *Meghna*

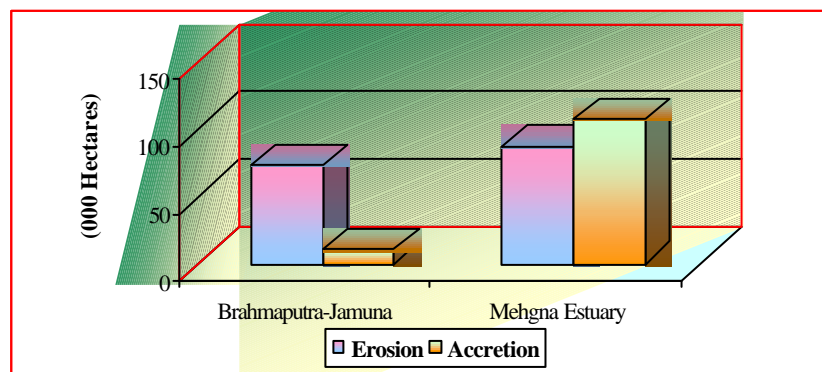


Table 3.1.4 Types and Extent of Land Degradation

Type of Land Degradation	Area under different degrees of degradation (Mha.)			Total Area (Mha)
	Light	Light	Light	
Water erosion	0.1	0.3	1.3	1.7
Riverbank erosion	-	1.7	-	1.7
Soil fertility decline	3.8	4.2	-	8.0
P deficient (for HYV rice)	5.3	3.2	-	8.5
P deficient (for Upland Crops)	3.1	2.5	-	5.6
K deficient (for HYV rice)	4.0	3.4	-	7.4
K deficient (for Upland Crops)	2.1	5.4	-	7.5
S deficient (for HYV rice)	4.4	3.3	-	7.7
S deficient (for Upland Crops)	4.1	4.6	-	8.7
Soil Organic Matter Depletion	1.94	1.56	4.05	7.55
Water logging	0.69	0.008	-	0.7
Salinization	0.29	0.43	0.12	0.84
Pan formation	-	2.82	-	2.82
Acidification	-	0.06	-	0.06
Active floodplain	-	-	-	1.53
Deforestation	-	0.3	-	0.3
Barind	-	-	-	0.773

Source: Karim and Iqbal, 2000

particular, loss of land leaves rural people declassed, and alienated from the main stream of society and culture that is based on land as a measure of wealth. Extensive erosion of riverbanks renders thousands of people homeless every year, and compels them to leave the affected areas in search of new settlements. It has been estimated that each year over one million people are affected by riverbank erosion (REIS, 1985).

Waterborne land degradation of various types in a locality is often immediately noticeable and evident to the people. However, degradation caused by direct human interference is often a slow process and the community does not realize the effect immediately. They keep themselves satisfied with the immediate gain. In-depth impact studies on various aspects of land degradation are inadequate at the country level. But the general consensus are agricultural yield reduction and displacement of human populations resulting from degradation of soil quality and land, which also have social and economic implications.

A study by Pike and Yaho showed declining trend of the output from high yielding rice varieties,

almost without exception, in all areas due to continuous waterlogging in the rice fields. The field personnel of the Directorate of Agricultural Extension (DAE) of the Ministry of Agriculture have also authenticated these findings. Most of the farmers who cultivate a land for more than 5 years continuously with irrigated HYV rice complain of a considerable decline in land productivity with time. At present, they are using higher doses of fertilizers and pesticides to get the same yield they got in the earlier years.

In addition to lowering the inherent soil fertility, continuous waterlogging also adversely affects land by:

- Spreading hydrophytic soil-borne pests and diseases, which become difficult to combat or eradicate as fields remain waterlogged continuously, season after season;
- Decreasing the bearing capacity of soils, particularly in some deep silty clay loam soils, making it difficult for farmers to work it.

Mono-cropping patterns in the country are also responsible for the deterioration of soil quality and productivity of land due to intense use of chemical

fertilizers and pesticides, and deteriorating soil quality (Karim *et. al.*, 1998). This is emerging as an important issue regarding sustainability of the cropping pattern and productivity. Already, Bangladesh is experiencing a decline or stagnation in the yield of many crops. According to Bangladesh Rice Research Institute (BRRI), 30 cropping patterns observed in 1997 of which 28 cropping patterns were found to have paddy as a component. The noteworthy feature of the findings were that nine all-rice patterns occupied 60 per cent of the total area covered by 30 cropping patterns (Karim and Iqbal, 2000). The deleterious effects of continuous wet-culture of rice were seen in the declining yields, and reduced availability of soil nutrients, particularly sulphur and zinc. There is also a decrease in soil organic content, due to decreasing practice trend in legume, green manure and jute-based cropping.

Salinity is a problem for cropping in the dry season. But in pre-monsoon and monsoon months, salinity is no longer a limiting factor. As a result, it appears to be possible to cultivate *Aman* varieties of rice in those areas between late May and September. However, even in such cases, the expected yield reduces to a certain degree depending on the soil salinity concentration (Karim *et. al.*, 1990).

Shifting and hill cultivation in Chittagong district not only degrade land productivity, but also causes excess runoff. This accelerates soil erosion and causes flash floods. The additional effect, other than loss of the sloping land, is that soil particles from erosion move down the slope, and are deposited on the riverbed, in the adjoining basins and over flat alluvial land. The beds of rivers and deep basins have been raised, which has affected drainage condition, and infertile soil material is spread over flat alluvial land burying fertile topsoil. Kaptai reservoir is now severely threatened by slow rising of the bed due to deposition of sediments coming in with the river water as a results of shifting cultivation in the surrounding hills. The siltation rate of the Kaptai reservoir is given in the Water Pollution and Scarcity chapters in detail. These kinds of land degradation phenomenon are also common in the northern piedmont areas, and foothills of Sylhet and Comilla.

The most adverse effect on the land caused by the rural road network is drainage congestion. Most of these roads have inadequate number of culverts, because the authority in charge of construction

often lacked the expertise on drainage needs and also had limited technical capability to determine the sites where culverts were needed. As a consequence, apart from the creation of man-made floods, during heavy rainfall the floodwater recedes slowly, so that agricultural land remains waterlogged for a longer time. This limits the cultivation of early high priced *Rabi* crops such as mustard, lentil, wheat, etc. Now farmers in the meander floodplain areas often complain that in their fields “*Joo*”, i.e., the optimum moisture required for sowing and germination, is present much later than a few years ago. Due to this, ploughing of the land for *Rabi* crops is delayed. Farmers are now compelled to grow late *Rabi* crops such as *Kheshari*.

There is no doubt that loss of land due to riverbank erosion causes not only morphological changes in the land, but also in the socio-economic condition of the affected people. A study by the Centre for Urban Studies (CUS) shows that riverbank erosion led to displace people losing stability in their lives and social status (CUS, 1988). The reality is that displaced people suffer terribly not only from loss of their land and housing, but also from a lack of psychological and social assimilation in the new places they settle. They are usually regarded as unwanted wherever they settle either in the cities or in new rural areas.

When riverbank erosion claims land and homesteads, the affected people have no alternative, but to move in search of new land and shelter. Many of them migrate to cities and are absorbed in urban informal-sector activities. The presence of hundreds of uprooted families on the 86 Km stretch of the BWDB embankment from Kazipur to Chouhali, via Serajgonj, testifies the magnitude of the riverbank erosion problem in the mid *Jamuna* floodplain. According to an estimate, about 8,000 households have become squatters on the embankment (Zaman and Babla, 1985).

Besides its social and environmental aspects, the economic implications of land degradation are tremendous. An assessment has been made in terms of production loss of crops and additional agricultural input necessary to maintain soil nutrients. It was found that the total economic cost of land degradation exceeds to 2 billion US dollars per year, as presented in detail in Table 3.1.5.

The presence of arsenic in the groundwater has been noticed in Bangladesh, and concerns over the use of

Table 3.1.5 Estimated Cost of Land Degradation in Bangladesh

Nature of Land Degradation	Physical Quantity of Loss Output	Amount (mt/yr.)	Cost (Million US \$/yr.)
Water Erosion	Cereal Production Loss	1.06	140.72
	Nutrient Loss	1.44	544.18
Fertility Decline	Cereal Production Loss	4.27	566.84
	Additional Agricultural Inputs	1.22	461.04
Salinity	Production Loss	4.42	586.75
Acidification	Production Loss	0.09	11.95

Source: BARC, 1999

arsenic contaminated groundwater for irrigation have emerged. It is yet to establish whether arsenic has any implication on yield reduction or whether it is entering the food chain, which would have serious health implications.

3.1.5 RESPONSES

Many human activities are based on land, and therefore are influenced by unwise and improper use of land resources. A number of stakeholders are involved in land use and land management, from both the government and private sectors. The demands of a growing population is the prime driving force that lead to deterioration of the quality and quantity of soil and land. A number of policy measures and practices have been initiated over the last decade to mitigate these. However, implementation of these measures are not adequate to combat land degradation.

The most important policy measure that is required for addressing land degradation is an integrated land use policy with respect to agriculture, industry and environment. Noting the importance of such a land use policy, the Government of Bangladesh has already made some progresses in this direction. A draft land use policy has been prepared, which is under discussion for government's approval.

3.1.5.1 Institutions

A number of institutions are involved in addressing issues related to land and preventing land degradation, ranging from the legal to management. The Ministry of Land particularly deals with legal aspects of land through their different wings. They are also associated with the land acquisition process for development work. The Ministry of Agriculture through the Bangladesh Agricultural Research Council (BARC) deals with productivity aspects of land. Under the same ministry, the Department of

Agricultural Extension (DAE) undertakes extension of the research outcomes of the institutes mentioned above. The Department of Environment (DoE) under the Ministry of Environment and Forest (MoEF) deals with aspects of land pollution.

3.1.5.2 Major Policy Responses

Draft Land Use Policy

A strategy for sustainable development of land resources require a comprehensive National Land Use Policy (NLUP). This needs to be concerned to introduce multi-disciplinary and inter-sectoral approaches to ensure optimum use of land, protect land from degradation, reclaim unutilized or degraded land for suitable use and improve land resources for future generations. The Ministry of Land has taken the initiative and prepared a Draft Land Use Policy for Bangladesh.

Some salient features of the Draft Land Use Policy are as follows;

- **Land and Agriculture:** Agricultural land should be used as per national agricultural policy, and acquisition of existing and potential irrigated land should be stopped completely. Existing cropland cannot be converted to other non-agricultural uses. In the case of unavailability of land for non-agricultural uses, less productive land can be acquired.
- **Land and Forest:** Extensive reforestation is needed to enhance the overall environmental condition of the country. It is necessary to implement Environment Policy 1992 and Forest Policy 1994.
- **Land and Settlement:** Unplanned rural settlement should be addressed by introducing a comprehensive housing policy, incorporating city corporations, metropolitan areas and *upazilas*. Local Government can play a vital role to minimize transformation of good agricultural land to settlement.

- **Land and Industry:** Industrial development is necessary for development, and Bangladesh obviously needs it. Land acquired by the Bangladesh Small and Cottage Industries Corporation (BSCIC) should be used properly, and new industry should be discouraged within a range of 10 km. As most of the industries were found very close to major roads, it is also proposed that 500 meters of land on both sides of the main road should be dedicated to industrial development.
- **Land and Wetland:** Highlighting the importance of wetlands, advocate for implementing Fisheries policy as a basis for wetland use.
- **Land and Tea and Rubber Garden:** Existing land under tea and rubber gardens cannot be used for other purposes, and valuable trees cannot be harvested in an indiscriminate manner.

In addition, the Land Use Policy also highlights other uses of land for different social and cultural purposes. Certified land ownership is one of the important aspects of the land use policy aiming at reduction of ownership-related problems and crime. For implementing the land use policy successfully, it emphasizes mass awareness programs for the general population and government administration.

Agriculture Policy 1999

Very recently the government has approved the Agricultural Policy of 1999. The major thrust of the policy is increased food production, and to address food and nutritional insecurity issues through self-sufficiency. It emphasizes environment-friendly, sustainable agriculture, and strengthening of agro-forestry programs of government and non-government organizations. It also highlights the need for frontier research, for example, on biotechnology and use of GIS based information.

Integrated Pest Management Policy, 2000

Integrated Pest Management (IPM) activities started in 1981, and have already passed through several phases of research and extension. IPM has an immense contribution in reducing the use of pesticides for crop production. Results show that it has the potential to increase crop production directly and yet contaminate soil very little. Considering these benefits of IPM, the Government has initiated the National Integrated Pest Management Policy in 2000.

Integrated Plant Nutrient System (IPNS)

Integrated Plant Nutrient System (IPNS) is a new concept to combat land degradation, particularly to address degradation of soil and land quality, since it uses a need-based nutrient application. In IPNS, the amount of nutrient application is specifically determined through diagnostic testing and estimation of the inherent nutrient status. Then there is a recommended application of a mix of organic and inorganic nutrients, including use of Biological Nitrogen Fixation (BNF). This system ensures the actual need for application of agricultural inputs and avoid excess application. Proper extension and large-scale adoption of this concept will reduce land degradation in terms of soil quality, land productivity loss and pollution by nutrients and nutrient availability (Iqbal, 2000).

There are other national policies and measures that have indirect positive impacts on combating land degradation. The noteworthy policies are the National Environment Policy, National Environment Conservation Act and Rules, National Forestry Policy, National Conservation Strategies, and the Strategic Plan for National Agricultural Research.

3.1.6 OPTIONS AND MEASURES NEED TO COMBAT LAND DEGRADATION

A comprehensive study at the country level on land degradation, covering all its aspects ranging from the physical to economic, is absent. However, it is clear that the quality of land has deteriorated, and its impacts are visible. Over the last decade, crop yield has declined due to deterioration of physical and chemical properties of land and soil. It would be useful to establish a baseline survey on which future monitoring and assessment of further deterioration or improvement could be based.

The country has a number of policies to deal with land degradation, but with limited implementation. The existing policies must be implemented, and a number of new activities should be undertaken in the immediate future to address land degradation. Research and its extension to practice are the most important steps that should start without delay. Brief descriptions of future needs, along with potential local stakeholders to undertake solving them, are presented in Table 3.1.6. A strategy is also required to obtain support from international agencies.

Table 3.1.6 Options and Measures to Arrest Further Land Degradation and Improve the Existing Situation.

Option	Outcome	Actors
Policy		
National Land Use Policy: <i>Comprehensiveness, long-term vision, people's participation</i>	Land Zoning will help sustainable land management and its development for different uses, utilization in the newly accreted fragile land in the estuary	Ministry of Land, Ministry of Agriculture, Ministry of Industry, Ministry of Environment and Forest, Ministry of Water Resources, Business community
Appropriate Cropping Pattern: <i>Adjustment of cropping patterns on a large scale incorporating legume/green manure crops and crop diversification</i>	Balance cropping patterns. Improvement of organic content of soil and sustainable agricultural production	Ministry of Agriculture along with its different wings (BARC, NARS, DAE, etc.)
Research		
Assessment and Monitoring: <i>Survey of the present state of land degradation and impacts, cropping and land capability</i>	Reflection of real situation of land degradation and extent of its severity will help to identify future course of actions required for addressing land degradation	Ministry of Agriculture along with its different wings (BARC, NARS, DAE, SRDI, etc.), Ministry of Environment and Forest, Ministry of Water Resources, Ministry of Planning
Restoration of Degraded Land: <i>Introduction of appropriate cropping patterns, introduction of salt tolerant varieties, soil conservation, and watershed management</i>	Improvement of soil quality, crop production in saline soil and restrict land degradation.	Ministry of Agriculture along with its different wings (BARC, NARS, DAE, etc.), Ministry of Environment and Forest, Ministry of Water Resources
Watershed Management: <i>Catchment based watershed management</i>	Arrest erosion in the hill slopes and improve gradual siltation in the floodplain	Ministry of Water Resources, Ministry of Agriculture Ministry of LGRD and Ministry of Environment and Forest
Extension		
Balanced use of Chemical Fertilizer and Adoption of IPNS	Improvement of soil quality, increase crop production and restrict land degradation	Ministry of Agriculture along with its different wings (BARC, NARS, DAE, etc.)
Mass Awareness and Motivation	Improvement of soil quality, increase crop production and restrict land degradation	Ministry of Agriculture along with its different wings (BARC, NARS, DAE, SRDI, etc.), Ministry of Information

Source: SoE Study Team

3.1.7 CONCLUSION

Land is an important natural resource that has direct and indirect linkages with human being in every sense such as production system, economic activities, and social and cultural more. The country has a reasonably good number of policies to combat land degradation, but they are not fully implemented yet.

There are two major constraints in preventing land degradation. The first one is the high population pressure on land, especially in the central, west and northwest parts of the country. In these regions, the exploitation of biomass due to a prevalent energy crisis appears to have exceeded the carrying capacity of the land, and led to encroachment on natural forests in the Chittagong Hill Tracts and Madhupur. The second constraint is the absence of a comprehensive national land use policy. However, a draft land use policy has emerged as the follow-up program of the NEMAP, and is in place for wider

discussion and government approvals. It needs to be emphasized that a plan to prevent land degradation must begin with strengthening of knowledge regarding the susceptible areas.

There is a wide gap between awareness of land degradation problems and actions necessary to combat them. Land degradation in many areas goes unnoticed from generation to generation, and therefore the concept of land resource conservation fails to attract politicians and planners. The scientists are worried about and warning everyone on the use of continuous irrigation, application of chemical fertilizers, use of good agricultural land for non-agricultural purposes, the lack of an integrated approach towards construction of rural road networks, problems with coastal polders, conversion of ecologically rich wetlands for single *Boro* crop production, and so on. However, they are often disregarded and the common attitudes of the common people is that they know about their land.

Politicians, decision makers and planners often do not see the land as the scientists do. The scientists see the land as a natural body, with its own delicate balance, and that problems and consequences can arise from its mistreatment. Farmers in general, particularly small farmers, are suspicious of innovations and are not easily convinced to use scientific methods, which would benefit them from resource conservation programs in the long run.

Present knowledge about the present status of the land degradation process and its level of impacts on national development and rural livelihood system is inadequate, and definitely requires further investigation and research. The potentiality of preventing further degradation in the future is uncertain, as the country suffers from a lack of innovative technology and adoption of recent technologies from outside the country, a low level of education and social awareness, and limited enforcement of laws and regulations. Therefore, in order to combat land degradation and to attain sustainable land management and development, it is very urgent to build institutional capacity to conduct field level research and apply the results through extension programs along with enabling policy makers to take necessary decision and to undertake appropriate mitigation measures.

Reference

- BARC (1997) Land Degradation Situation in Bangladesh. Soil Division, Bangladesh Agricultural Research Council, Dhaka, Bangladesh.
- BBS (1994) *Statistical Year Book of Bangladesh*, Bangladesh Bureau of Statistic, Ministry of Planning, Dhaka, Bangladesh.
- BBS (1998) *Statistical Year Book of Bangladesh*, Bangladesh Bureau of Statistic, Ministry of Planning, Dhaka, Bangladesh.
- CUS (1988) *Composite Score map of Socio- economic Development of Bangladesh by Upazila*, Center for Urban Studies, Dhaka University, Dhaka, Bangladesh.
- Elahi, K.M. (1985) Riverbank Erosion and Floods in Bangladesh: Need for Inventory and Planning, In *REIS*, Bulletin No. 2.
- Farid, A.T., Iqbal, A. and Karim, Z. (1992) Soil Erosion in the Chittagong Hill Tracts and Its Impact on Nutrient Status of Soils, *Bangladesh Journal of Soil Science*, Vol. 23 (1&2), Page 92-101.
- Hunt, J.M. (1984) *Area Development of Barind Tract*, Dhaka, Bangladesh.
- Iqbal, A. (2000) The Bangladesh National Report on the Land, Water and Plant Nutrition in Bangladesh, *Regional Workshop on Land Resources Information System in Asia*, Manila, Philippines.
- Islam, M.N. (1986) Alternative Adjustment to Natural Hazards; Implication for Bangladesh, *Presidential Address at the 11th Annual Bangladesh Science Conference*, Rajshahi, Bangladesh.
- IUCN (1991) *National Conservation Strategy of Bangladesh (Draft)*, International Union for Conservation of Nature and Natural Resources; Ministry of Environment and Forest, GoB, Dhaka, Bangladesh. P. 83.
- Karim, Z., Hussain, S.G. and Ahmed, M. (1990) *Salinity problems and crops intensification in the coastal region of Bangladesh*, Bangladesh Agricultural Research Council, Dhaka, Bangladesh.
- Karim, Z., Mia, M.M.U. and Razia, S. (1994) Fertilizer in the National Economy and Sustainable Environmental Development, *Asia Pacific Journal Environment and Development*, 1 (2): 48-67.
- Karim, Z., Hussain, S.G. and Rahman, M. (1998) *Chemical Fertilizer for Increase Crop Production Poses on Threat to Soil Pollution in Bangladesh*, Bangladesh Agricultural Research Council, Dhaka, Bangladesh (unpublished).
- Karim, Z and Iqbal, M.A. (ed.) (2000) *Impact of Land Degradation in Bangladesh: Changing Scenario in Agricultural Land Use*, Bangladesh Agricultural Research Council, Dhaka, Bangladesh, (in press).
- MES (1999) Technical Note 023. Meghna Estuary Study. Dhaka Bangladesh.
- Pike, J.G. and Yano, T. (1986) *Investigation of Lands with Declining and Stagnating Productivity Report*, Dhaka, Bangladesh.
- Rahman, M.R. (1991) *Towards Sustainable Development Land Resources in Bangladesh*, Ministry of Environment & Forest and National Conservation Strategy Secretariat, Bangladesh Agricultural Resource Council, Dhaka, Bangladesh.
- REIS (1985) *Riverbank Erosion Study*, Jahangirnagar University, Bangladesh and University of Manitoba, Canada.
- Shahid, S.M. (1994) *Data Collection and Analysis of Land Degradation*, Bangladesh Report, Bangkok, Rapa Publication; 1994/3.
- SRDI (1997) Task Force Report. Soil Resources Development Institute, Dhaka, Bangladesh.
- UNDP (1989) Bangladesh Agriculture Sector Review.
- Zaman, M.Q. and Babla, A.I. (1985) *Rural Baste; A Socio-economic Background to the Squatter on the Jamuna Right Bank Embankment*, Dhaka, Bangladesh.

