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Land Desertification-An Emerging Threat to Environment and Food Security of Pakistan

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Abstract: The natural resource base of land, water and vegetation in arid and semi arid areas is highly fragile and greatly vulnerable to degradation. There is a serious problem of desertification in many parts of Pakistan. Population pressure along with the demand for more food, fodder and fuelwood has generated a chain of interrelated economic, social and environmental issues associated with the land degradation inside Pakistan. A variety of natural and human factors are contributing to desertification and severely impairs the biological productivity of lands across the country, including dwindling vegetation cover, overgrazing, flooding, over exploitation of water and land resources, over cultivation of marginal lands, deforestation, soil erosion, salinization, sodication and the use of inappropriate technologies. Unsustainable agricultural activities including inadequate soil conservation, cultivation of steep slopes, cultivation without adequate fallow periods, unbalanced fertilizer use and improper irrigation management coupled with the misuse of prime agricultural land for urbanization/industrialization had a devastating impact on land resources. The increased pressure on land with low productivity and environmental pollution through industrial wastes has further exacerbated the prevailing condition. In spite of the concerted national efforts to mitigate the effects of drought, combating desertification is still one of the major challenges to the people of the country. The action necessary to help avert desertification is to educate people as to the value of precious land and water resources. The present deserted situation is directly related to the failures of the unrealistic resource management policies. Various approaches are being applied to arrest the menace of desertification. The institutional set-up for formulation and implementation of programs and policies is being strengthened in the country. Numbers of land reclamation projects have been launched. The activities and efforts already underway by several public and private organizations, departments, NGOs and rural support programs to combat desertification are required to be strengthened, integrated and supplemented through a nationally supported, coordinated and monitored system. This study reviews some of the causes of desertification, identifies the patterns of land degradation and highlights the future prospects of combating desertification in Pakistan.

Key words: Agriculture, desertification, deforestation, salinity, soil erosion, Pakistan

INTRODUCTION

The United Nations Convention to Combat Desertification (UNCCD) defines desertification as 'land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities. Land degradation is defined as reduction of its potentiality as a result of one or more processes arising from human activities and habitation pattern such as I) soil erosion caused by wind and/or water ii) deterioration of physical, chemical and biological or economic properties of soil and iii) long-term loss of natural vegetation. It is a reduction or loss of biological or economical productivity of rainfed cropland, irrigated cropland, or range, pasture, forest and woodlands. Importantly, land degradation is referring generally to the reduction or loss of the biological or economic productivity and complexity of land, whereas desertification is specifically referring to the degradation of drylands. Desertification is considered as one of the major global environmental challenges we face today. The international community has long recognized desertification as major economic, social and environmental problem to many countries. Deterioration of soil and plant-cover has adversely affected nearly 50 percent of the land areas as the result of human mismanagement of cultivated and range lands. About 4 billion hectares or 1/3 of the earth's land surface is threatened by desertification, over 250 million people are directly affected and one billion people over 100 countries

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are at risk. Twenty four billion tons of fertile soils disappear every year (www.unccd.int). About 23 and 37% of the world cultivated lands are saline and sodic, respectively (Szabolec, 1989). According to Kovda and Szabolcs (1979) nearly 10% of the total land surface is covered with different types of salt-affected soils.

Land being the principal non-renewable natural resource encounters various threats. Desertification is a process whereby the productivity of land decreases due to numerous factors and is aggravated by droughts and probably climatic variations. Desertification reduces the potential productivity of land to support life, affecting wild species, domestic animals, agricultural crops and people. Desertification is a land degradation problem of major importance in the arid regions of the world and occurs due to reduced dryland vegetation. Overgrazing and wood cutting are responsible for most of the desertification of rangelands, cultivation practices inducing accelerated water and wind erosion are most responsible in the rainfed areas. This leads to the erosion and oxidation of fertile soil. Similarly, salinity triggered by excessive irrigation practice decreases soil fertility and lowers consequently the productivity of drylands. The inappropriate use of drylands, such as overgrazing, deforestation or inappropriate irrigation is mostly driven by demographic, economic and social-political factors. Climate change might further affect the chemical, physical and biological processes and thus contribute to desertification. In addition to vegetation deterioration, erosion and salinization, desertification effects can be seen in loss of soil fertility, soil compaction and soil crusting. The degraded arid lands jeopardize human well-being. People living in drylands have to use marginal land or to migrate to other areas.

Combating desertification can be done successfully using techniques already known if financial resources are available and political will to act is present. Several international, regional and national environmental agreements have been put in place to provide frameworks, guidelines and assistance to policy makers, scientist and people in the field. However, much has to be done to improve the political commitment and to overcome the lack of financial resources to provide better guidance and support for sound management plans and practices for the benefit of the people living in drylands. It is necessary to address political, social and economic constraints, globally and in the regions, to path the way for the sustainable management of drylands. This will include providing alternative livelihood opportunities, tenure security, appropriate and improved grazing and irrigation practices and even more important the support for the traditional sustainable management of drylands. The ecosystem approach as a strategy for the integrated management of land, water and living resources is thus of particular significance to drylands.

The economy of Pakistan is almost entirely dependent on agriculture. About 68 million ha of land area lies in the fragile regions receiving less than 300 mm rainfall annually. The country has high complex and diversified agro-ecological and socio-economic set up. The country, with 90% of its land classified as arid or semi-arid, is facing a growing threat from desertification through drought and soil degradation. One fourth of the country's land area which is suitable for intensive agriculture is seriously subjected to threats of wind and water erosion, salinity, sodicity, waterlogging, flooding and loss of organic matter. The location of Pakistan is in arid and semi-arid climatic zones and characterized by extreme altitudes and temperatures. High evapotranspiration and low rainfall are characteristics of arid and semi arid areas. The total geographical area of Pakistan is 79.6 million hectares, with a very large canal irrigated system mainly confined to Indus plain. The annual increase in population at 2.1% (Pakistan Economic Survey, 2003) forces over exploitation of soil and water resources. The per capita cultivated land is 0.16 ha (FAO, 2000). Sustainability of agricultural and environmental systems is the major concern in the country. There is a need to accelerate efforts for increasing agricultural production in view of the existing 148.2 million people and also growing population which is going to become 345.5 million in the next 50 years (UNO, 1999).

SOIL EROSION

Soil erosion implies loss or removal of surface soil material through action of moving water, wind or ice. Land use practice, vegetation cover, soil type and structure are other major factors related to soil and water erosion. Soil erosion in the water shed areas of rivers increases the sedimentation load, which ultimately reduces the storage capacity of dams. Water erosion is the widespread hazard in the region, caused mainly by excessive exposure of bare soil due to poorly managed logging operations, indiscriminate land clearance, widespread use of annual crops in farms, overgrazing, cutting of vegetation for fuel and inadequate management of runoff. Agricultural activities and overstocking has lead to the reduction of vegetation cover, resulting in the acceleration of both wind and water erosion. The soils in the Indus basin are recent and undeveloped. The surrounding mountains have some of the world's steepest and largest slopes. Intense summer rainfalls along with melting of snow in high mountains contribute to the soil erosion hazards.

Watersheds in upper Indus and its tributaries suffer from unfavorable soil and moisture regimes. Soil erosion has caused decline in soil fertility, water supply and reduced agricultural potential in Pakistan. During the rainy season, erosion causes floods and disturbance of socio-economic setup of farming community.

Wind and water erosion affect over 76% of the country's total area. Over 36% is being eroded by water and 40% by wind. Every year approximately one billion tones of soils are being lost, silting up precious dams and dumped into the Arabian sea. Northern mountains of Pakistan are the major source of water for Tarbela and Mangla dams. However, due to heavy soil erosion, caused by deforestation in the catchments, these reservoirs, which provide water for 90% of the food and fiber production in the country, are silting up, thus reducing the capacity of power generation and availability of water. Water erosion shortens the life span of major reservoirs, irrigation system and reduces their efficiency. Rainfed lands are subjected to heavy soil erosion, primarily due to the improper land use by crop cultivation, livestock grazing and illegal removal of vegetation cover.

Water erosion is prevalent in the northern hilly areas, Pothwar Plateau, the eastern flanks of Punjab situated in the foothills of Hamalayas and the western hilly areas. In northern mountainous areas with steep slopes, the water erosion is low in the areas with permanently closed canopy forests, while the erosion is greater in areas with the arable crops on steep slopes. The rainfall in these areas varies from 250-1000 mm per annum and they have uneven terrain. This type of landscape is vulnerable to the loss of soil and water. About 50% of the rainwater is lost as runoff. If half of this water could be saved, it would amount to about 6 million acre-feet (maft) of water, which is equal to the 2/3 of the usable capacity of Tarbela dam, enough to irrigate 4 million acres of land. The problem is being further aggravated by deforestation, overgrazing and faulty methods of cultivation.

High velocity wind storms cause severe movement of sand dunes depositing thick layer of sand on roads, railway tracks, waterways, crop lands and threaten village inhabitants. Deserts have acute problems of shifting sand dunes. Wind erosion has led to desertification of vast area of Thal, Cholistan, Mianwali, Muzaffargarh and D. G. Khan in Punjab; Thar in Sindh and vast areas of Baluchistan where rainfall is low, summer temperatures are high and the soil is loose and sandy. This type of erosion is significant in the areas where the habitation and watering points are trampled by the livestock. Over exploitation of rangelands for fuelwood and livestock grazing has exacerbated the prevailing situation in the large part of the country.

DEFORESTATION

Trees help controlling soil erosion, check run-off, reduce desiccation of crops and improve physical, chemical and biological properties of soil. Deforestation, over cultivation, excessive cutting of fuelwood and incorrect irrigation practices have aggravated the entire forest situation. Soil erosion increases on degraded grazing land with sparse vegetation cover, which led to siltation of rivers and channels. Decline in the soil fertility due to the removal of top soil results in the low production of forage, fodder, fuelwood, timber and grains. Deforestation is the root cause of land degradation. The forest area in Pakistan is about 5.2%, which is too low to meet the environmental as well as socio-economic needs of the country. Due to deforestation, forest cover is shrinking by 3.1% and woody biomass by 5% annually. The forest cover in the country has suffered in the recent past from indiscriminate cutting, overgrazing, poor management and man-made ecological changes. Deforestation is caused mainly by the collection of fuelwood, commercial logging, shifting cultivation and degradation through grazing and fire. Pakistan's deforestation rates are alarmingly high; threatening the lives of many Pakistani's who are depending for their livelihood. In Pakistan, as in much of the world, the most impoverished communities rely on natural resources. Deforestation can be attributed to rapid population growth, illegal logging, unsustainable use of natural resources and the minimal public participation in reforestation programs in the country.

Deforestation has increased desertification, erosion and silting of reservoirs. In this way the biological defenses against water logging and salinity are also deteriorated. The ability to resist soil erosion caused by monsoon rains is largely dependent on vegetation cover on the ground. Overcutting of vegetation/forest is taking place because of exploitation for timber, fuelwood and other products at a pace exceeding the rate of forest regeneration. The land is being cleared and causing soil erosion since the clearance of forest is not followed by good management. According to the FAO (1996) reports, the area under forest in Pakistan is 1.8 Mha and 77,000 ha are being lost annually because of ruthless cutting. If absolute annual loss were to continue at the same pace, the forests in Pakistan would be entirely gone by 2015. This is frequent in semi-arid region, where the fuelwood shortages are often severe. Destruction of vegetation in the area is for fuelwood. Due to increase in population, the consumption of household firewood would probably go up to 3% per year. The lopping of trees for commercial

purposes has also greatly accelerated forest depletion. Unrestricted livestock grazing is also a severe threat. Regional forest conditions portray a dismal picture. More than 50% of the original rain forests have been degenerated beyond economic viability. More than 1/3 of the country area has been classified as at risk of desertification. The arid coastal strips, arid mangroves areas are under increased environmental stress from reduced fresh water flows, sewage and industrial pollution and over exploitation of other natural resources.

OVERGRAZING

Over grazing is the major cause of desertification worldwide. The country suffers particularly from overgrazing of pasture land, a major cause of human-induced desertification. The people depend to a great extent on animal husbandry for their livelihood. On one hand, the low and variable rainfall results in reduced productivity of grassland. On the other hand, growing livestock populations exert pressure well beyond the carrying capacity of the pastures of the arid lands. Rapidly increasing domestic livestock population is the direct cause of degradation on rangelands and forests. The productivity of range lands is hampered by heavy livestock pressure. During period of feed scarcity, thousands of cattle, sheep and goats depend on fodder plants, which are lopped to the main stem. Unsystematic livestock grazing reduced the productivity of rangelands due to soil compaction, devegetation of fragile slopes, destruction of terraces and selective destruction of growing trees and shrubs. Overgrazing has brought down the productivity of rangelands to as little as 15-40% of their potential. Sixty percent of the natural grazing areas of the country have production levels lower than 1/3 of their biological potential. Overgrazing by livestock decreases vegetation and exposes the soil to water and wind erosion. As vegetation cover and soil layer are reduced, rain drop impact and run-off increases. A reduction in the plant cover also results in a reduction in the quantity of humus and plant nutrients in the soil and plant production drops further. As protective plant cover disappears, floods become more frequent and more severe. The process of desertification starts continuously. To halt desertification the number of animals must be restricted, allowing plants to regrow. Fencing is a valuable tool of preventing the domestic and wild animals from moving around the veld. Soils conditions must be made favorable for plant growth by mulching etc. Mulch reduces evaporation, suppresses weed growth, enriches soil as it rots and prevents runoff and hence erosion.

WATERLOGGING AND SALINITY

Because of the flat nature of the Indus plain, natural subsurface drainage through down-valley movement of ground water is restricted. The Indus forms the demarcation line between two of Pakistan's main topographic areas the Indus Plain, which extends principally along the eastern side of the river and the Baluchistan Plateau, which lies to the south-west. Persistent seepage over the years from unlined canals and large network of distributors and irrigation surpluses from the field have caused water table to rise close to the land surface creating water-logged conditions. Improper water management leading to salinization is the cause of deterioration of irrigated lands. The area under cultivation is 22 million hectares, of which over 16 million hectares is irrigated. About 6.3 million hectares are salt-affected and of which 1.9 million hectares is saline, 1.8 million hectares is permeable saline-sodic, 1.0 million hectares is impermeable saline-sodic and 0.03 million hectares is sodic in nature. It is estimated that 1.6 million hectares land have salinity in patches in four provinces. About 80% of the salt affected soils of Punjab and 56% of those of whole Pakistan are saline-sodic. The salt affected soils are mainly situated in Indus plain. Intensive and continuous use of surface irrigation has altered the hydrological balance of the irrigated areas. The estimated waterlogged area with water table depth within 3 meters is 9.37 million hectares, out of which 5.25 million hectares have water table within 1.5 m (GOP, 1997). Majority of salt affected soils are saline-sodic in nature (Muhammad, 1978, 1983) and cultivable land is being lost at an alarming rate of 0.02-0.04 million hectares each year (Sheikh, 1991). High evapotranspiration and low rainfall are responsible for inadequate leaching and consequently the accumulation of salts in the root zone. The annual increase in population at 2.1% (Pakistan Economic Survey, 2003) forces over exploitation of natural resources including soil. The per capita cultivated land is 0.16 ha (FAO, 2000). Sustainability of agricultural and environmental systems is the major concern in the country.

Lack of an effective drainage system to combat the twin menaces of waterlogging and salinity is the principal threat to the survival of irrigated agriculture in Pakistan. Irrigation without drainage, over irrigation and inefficient irrigation and drainage system, use of poor quality groundwater, redistribution of salts in the soil profile due to high water table and improper management of water and soil are the main causes of this twin menace (Zuberi and Sufi, 1991; WAPDA, 1996). A large part of the water diverted from rivers does not reach the field crops.

It is estimated that 45-50% of the water is lost from main canals, branches, distributors, main watercourses and farmers branches.

A wide range of measures are being applied to mitigate salinity in Pakistan. Salt affected lands are being rehabilitated through hydrological approach in conjunction with chemical and biological reclamation. The management techniques including land leveling and high efficient irrigation systems e.g., sprinkler and drip irrigation are introduced. Chemical amendments such as gypsum, sulfuric acid and farm yard manure are applied especially in sodic soils. The continuous recycling and reuse of saline-sodic groundwater caused an imbalance of salts in the root zone. The conjunctive use of good-quality and marginal waters through blending or recyclic application could minimize the adverse effects of poor-quality waters on land and water resources. The knowledge of soil amendments, water quality and leaching appears limited. One of the actions necessary to help mitigate the prevailing crisis is to educate people as to the value of management of land and water resources.

On account of certain limitations which are apparently related to insufficient supply of irrigation water, saline underground irrigation water, high cost of amendments, low permeability of soils, poor soil drainage and redistribution of salts in the soil profile due to high water table and improper on-farm management systems, the problem can not be tackled with complete success indicating that engineering approach is unlikely to achieve the desired goals. The use of salt-tolerant plants have been advocated for effective utilization and improvement of salt-affected soils since the alternative methods of extensive land reclamation and drainage are costly and difficult to apply especially by poor farmers. The improvement of major salt affected area for agricultural purposes through the cultivation of salt tolerant crops, grasses, shrubs and trees seem to be result oriented. These measures will provide a key role in the success of agriculture. Saline-sodic soils are deficient in organic matter and impermeable in nature. Bio-saline agriculture technique uses saline lands to create income for the farmer without the need for expensive drainage and reclamation work. Deep rooted plants and trees with high evapo-transpiration demand would provide biological drainage resulting hospitable environment for subsequent vegetations in the abandoned saline areas.

Much of the land which may not be reclaimed can be used profitably by growing economically salt-tolerant trees and shrubs species especially those of the genera *Atriplex* and *Eucalyptus*, *Chenopodium*, *Suaeda*, *Salicornia*, *Kochia*, *Sesbania*, *Salsola Juncus* and others. In an investigation on salt-tolerant shrubs, *Atriplex* species displayed greater potential in highly saline soils (Irshad *et al*. 2000). Several bio-saline agricultural projects are being carried out involving exotic and indigenous salt-tolerant plant species in various parts of the country for utilization of marginal lands. Salt-tolerant grain, fruit and fodder species have been identified. The use of salt-tolerant plants along with other appropriate combinations would provide a new opportunity for the effective utilization and improvement of saline wastelands in Pakistan.

UNSUSTAINABLE MANAGEMENT

The unsustainable agricultural activities include inadequate soil conservation, cultivation of steep slopes, cultivation without adequate fallow periods, cultivation of fragile or too shallow, unbalanced fertilizer use and improper irrigation management has had a devastating impact on land resources. Soil does not have to be washed or blown away for its productivity. Through improper soil and water management, a soil's properties including its fertility may be altered or lost. Excessive cultivation, for example, can wreck the structure of some soils so that they are no longer capable of holding enough moisture for growing plants. Soil can also become degraded through loss of nutrients-chiefly nitrogen, phosphorus and potassium-if these are not replenished to maintain soil fertility. Besides being lost through erosion, nutrients are also depleted by the crops themselves, particularly if the same crops are grown on the same land year after year. Plant nutrients are leached down during the intense rainstorms, especially on unprotected land. There is a consensus that farming is removing more nutrients from the soil than are being put back.

Soil compaction is still another destroyer of the soil. Sometimes it results from repeated passes over the same field with heavy machinery, particularly when the field is wet. It can also result from the hooves of grazing animals pounding down the soil too often in the same area, as they do around the only waterhole for miles. Compaction is not easy to correct. The indirect cause of land degradation is the population explosion at the rate of 3% population growth. The ultimate consequence of continued population pressure is the shortage of land especially in urban areas. Population explosion created constraints like saturation of good land, attempt to obtain multiple crops by irrigating unsuitable soils and ploughing of fallow land etc. Migration of people from rural to urban areas created other social and economic issues on lands in the irrigated plains areas. The combination of rapid urban and industrial growth has made the problem more severe. Underground water

resources in western dry mountains of Baluchistan are shrinking, due to very little recharge, over exploitation of the meager quantity of water for horticulture and crop cultivation. The arid coastal strips and mangroves areas are under increased environmental stress from reduced fresh water flows, sewage and industrial pollution and over exploitation of other natural resources.

COMBATING DESERTIFICATION PROGRAMMES

Productive lands and healthy environment are the only gift worth passing to our next generations. Therefore, it is necessary for the sustainable future of Pakistan to cope with the land degradation problem on war-footing bases. Activities like soil and water conservation, dryland afforestation and rehabilitation of degraded rangelands and saline areas are being carried out since independence. Pakistan signed UN Convention to Combat Desertification in October, 1994 which was ratified in February, 1997. The turning point in the awareness and need for the serious thinking and concerted efforts to address problems relating to desertification/land degradation came in late sixties/early seventies. The earlier projects, however, lacked community participation perspectives and imperatives. Earlier strategies and policy initiatives to address serious issues of land degradation and resource conservation resulted in the compilation and preparation of National Commission Report on Agriculture (1988), Forestry Sector Master Plan (1992), National Conservation Strategy (1992), Sarhad (NWFP) Conservation Strategy (1996) and National Master Agricultural Research Plan (1996). These documents have already resulted in widespread acceptance of natural resources and proper land use; new ways of working between sectors; institutions and disciplines; methodologies for consulting, communities, NGOs; involvement of women and group of Pakistan policy analysis experts. Pakistan has also signed and ratified the UN Convention on Biological Diversity. A climate impact assessment and adaptation strategies study was completed in 1998. The Ministry of Environment Govt. of Pakistan is responsible to promotion, education, public awareness and capacity building, review and update of National Action Program, strengthen interagency coordination and implementation of the specific program for combating desertification. Recognizing desertification as a severe and growing problem, Pakistan's environment ministry together with the United Nations Development Program (UNDP) has launched a national project to address the pressing issue: Sustainable Land Management to Combat Desertification in Pakistan. To combat desertification, the IUCN has also started two mangrove rehabilitation programs, the one in Sindh involves pilot testing of bio-saline agriculture and aquaculture techniques, while the Baluchistan project focuses on the promotion of appropriate water conservation methods, including efficient irrigation and innovative water recharging techniques. A realistic land management approach is essential for desertification in arid and semi-arid areas. To empower the people at grass root level, new district governments and local councils established will facilitate transfer of authority and responsibility to manage and develop natural resources on sustainable basis at local level, according to the need and aspiration of people. Funds are being provided at present for implementing resource management and development projects by European Union, GEF, FAO and UNDP and other donors. These projects are being implemented by Government Institutions, IUCN and WWF. Technical cooperation is needed to improve and develop the capacity in remote sensing, early warning, assessment and mapping of desertification, management of information systems, monitoring, evaluation and impact assessment.

A large number of reclamation projects on waterlogging and salinity have been initiated. Water and Power Development Authority (WAPDA), provincial irrigation and On-farm water management departments are combating secondary salinization in the country. The WAPDA has completed several salinity control and reclamation projects in Punjab, Sindh and North-Western Frontier Province covering a gross area of 7.81 million hectares. The objectives of these projects were to lower the groundwater table through tile drainage system and supply additional water for irrigation and reclamation of saline soils.

National Drainage Program was launched to minimize drainage surplus and facilitate eventual evacuation of the saline drainage effluent from Indus Basin to the Arabian Sea. The project was designed for remodeling/extension of existing surface drainage, rehabilitation of saline groundwater well, installation of pipe drains and rehabilitation of canal command pilot areas. The project will also support research to improve the technical knowledge based on irrigation and drainage and studies to improve sector policies and planning. Left Bank Outfall Drain Project was recently established in Sindh Province to provide drainage to 0.5 m ha of lands. The purpose of the canal is to provide an outfall for saline effluent to the Arabian Sea. National program for improvement of water courses has been initiated across the country covering 85 thousand water courses within period of 5 years at a total cost of more than 1.1 billion US dollar. Canal, watercourses lining and desiltation of canals would reduce seepages, save water and enhance water delivery.

There is urgent need to address land desertification through multi-disciplinary approach based on scientific principles. The research networks for assessment and monitoring of land use planning and management is essentially important. The activities and efforts already underway by public and private organizations to combat desertification should be strengthened and supplemented by well coordinated system. This report focuses on the prospects and challenges of combating desertification for bright Pakistan.

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