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OASIS Country Report 3

Review of Available Knowledge on Land Degradation in Pakistan

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Review of Available Knowledge on Land Degradation in Pakistan

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Feedback:
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CONTENTS

EXECUTIVE SUMMARY

Review of Available Knowledge on Land Degradation in Pakistan

This publication reviews the historical and current literature on land degradation in Pakistan.

It is intended as a useful guide for Government officials, donor agencies, NGO's, farmers, rural groups and others in determining a route forward to combat land degradation in-country and in delivering practical assistance on the ground.

Desertification and degradation affect about 68 million hectares of fragile lands across the country. The problem is exacerbated by the fact that Pakistan has a highly complex and diversified agro-ecological and socio-economic structure that makes it difficult to control the different types of land degradation. Such damage is mainly due to water erosion, wind erosion, depletion of soil fertility, deforestation, unsustainable livestock grazing and water logging practices (little recharge and overexploitation). These problems of land degradation in Pakistan are aggravated by water scarcity, frequent droughts and mismanagement of land resources that contribute to reduced productivity and increased rural poverty.

Land degradation has been worsening in the absence of effective land policies and political will to address the long-lasting effects from land degradation. At present there is no organization in the country responsible for coordinating and monitoring the use of land according to its potential.

The Pakistan government has recently launched the National Action Plan as a strategy to combat desertification. This strategy aims at implementing a land policy plan to overcome degradation through the three policy pillars of conservation of natural resources, sustainable development and improved efficiency in the use and management of resources. The priority programs to recover degraded lands include projects of afforestation, improved crop production in dry lands, improved range/livestock feeding and management, soil and water conservation, water harvesting and increased water use efficiency, rehabilitation and reclamation of saline/sodic soils, improved drainage and on-farm management, improved production of horticultural crops, improved biodiversity.

The sustainable management of a huge, inter-linked and very complex natural resource base is the single most challenging long-term task for natural resource managers in Pakistan and requires the development of world-class capacity in adaptive management of the natural resources, development and management of water resources and new institutional arrangements involving communities in natural resource management.

Pakistan has been striving to streamline the use of natural resources in a manner to provide a decent to living to its more than 117 million peoples, further growing at annual rate of around 2%. There is real urgency in merging the economic and the environment in decision making and in the use of economic instruments rather than regulation to control land degradation.

The authors welcome comment and feedback on this report—Dr. Muhammad Azeem Khan (azparc@yahoo.com)

Introduction

BRIEF DESCRIPTION OF THE LAND RESOURCE BASE IN THE COUNTRY

Pakistan is predominantly a dry-land country where 80 percent of its land area is arid or semi-arid, about 12 percent is dry sub-humid and the remaining 8 percent is humid. Two-thirds of Pakistan's rapidly increasing population depends on dry-lands to support their livelihood mainly through agro-pastoral activities (GOP, 2006). However, like many other developing countries dry lands in Pakistan are severely affected by land degradation and desertification due to unsustainable land management practices and increasing demands on natural resources (Zia et al 2004). This causes enormous environmental problems, including degradation of dry-land ecosystems, loss of soil fertility, flash floods, loss of biodiversity, reduction in land productivity, soil erosion, water logging, salinity, in addition to other problems associated with rapid population growth - all are putting pressure on natural recourses. The situation is further aggravated by water scarcity, frequent droughts and mismanagement of land resources, contributing to desertification and reduced productivity, consequently increasing rural poverty.

Some threats of land degradation are greater than others in terms of their manifestation: Water logging and salinity, as a result of poor irrigation practices, affect 14 million hectares, while deforestation and overgrazing affect 11 and 24 million hectares, respectively. While deforestation is the cause of the most widespread land degradation in river basins (in Sind and the Punjab), overgrazing (mostly deforestation, water and wind erosion) affect the greater dry land and upland areas (Balochsitan, North West Frontier Province (NWFP) and parts of Punjab) causing considerable damage to the integrity of ecosystems and provision of essential ecosystem services - soils, trees, water and biodiversity (GOP, 2006).

ECONOMIC SIGNIFICANCE OF LAND DEGRADATION IN THE COUNTRY

A number of researchers, including Naqvi et. al. (1992, 1994) and Mellor (1988) believe that agriculture must maintain a growth rate of more than five percent in order to ensure a rapid growth of national income, attaining macroeconomic stability, effective employment of growing labor force, securing improvement in distributive justice and a reduction in rural poverty in Pakistan. Realizing the importance of the agriculture sector in the national economy, the Medium Term Development Framework (MTDF) 2005-10 envisaged an average growth rate of 5.2 percent for the agriculture sector with major crops sub-sector growing at an even higher average rate of 7 percent during this period.

It is widely maintained that the growth in agricultural output in the past was mainly attributed to many factors, including the development of irrigation infrastructure, increased cultivated area, enhanced land use intensity, and augmented use of various inputs and, to a lesser extent, to improved productivity. Many agricultural and development experts believe that most of these factors would only make a marginal contribution towards agricultural growth in the future as most of the potential of these factors has already been exhausted. c In the example of the increased cultivated area, we find that out of the 79.61 million hectares of geographical area of Pakistan, about 23.39 million hectares were cultivated during 2006-07 as compared to the 14.99 million hectares in 1949-50. We realize that the cultivated area has increased by about 56 percent over a period of 58 years at a rate of roughly less than one percent (0.9 %).

Due to the fact that most of the best lands have already been brought under cultivation and that high investments have been made in bringing new land under cultivation, the expansion in cultivated area can only be expected to happen at a much lower rate than that in the past.

The national average cropping intensity increased from about 122 percent in 1980 to 142 percent in 2000 (Agriculture Census). The provincial average cropping intensity stood at 154, 130, 142 and 78 percent respectively in Punjab, Sindh, NWFP, and Balochistan respectively, during 2000. The cropping intensities increased over time in all the provinces except Balochistan (where it was highest in 1990).

The national average cropping intensity on marginal and small farms was 162 and 151 percent respectively during 2000. The average cropping intensity in irrigated area is expected to be even higher and in certain areas may be in the vicinity of 200 percent. This implies that the pressure on land resources is mounting over the time, especially on small and marginal farms (5 hectares or less). Such a high cropping intensity, along with low use of farmyard manure, unfit irrigation water resource use and unbalanced use of chemical fertilizers are having serious implications on soil health, especially for the sustainability of marginal and small farms.

Farmers' dependence over groundwater is not uniform across Pakistan. It varies according to climatic conditions, cropping patterns and availability of surface water supplies. However, about 60% of farmers depend upon groundwater to meet the crop water requirements. Punjab agriculture has become heavily dependent on groundwater and its quality also greatly varies from place to place, due to variation in origin, source of recharge and patterns of groundwater movement in the aquifers (Qureshi et al., 2003). Keeping this in view, further increase in agricultural production through enhancing cropping intensity would only have slim chances. Over-exploitation of existing land and water resources may result in further degradation and would therefore call for enhanced desertification processes.

HISTORY OF SOIL SURVEYS

In 1962, an inventory of soils in the country was initiated through a Soil Survey Project, undertaken by the Government of Pakistan with the assistance of the United Nations Development Program (UNDP), and the UN Food and Agriculture Organisation (FAO). The main purpose of this initiative was to assist the government in areas such as new land settlements, irrigation extension and drainage schemes, soil reclamation and conservation, afforestation and rangeland improvement, among others. In 1973, the Soil Survey Project - the Soil Survey of Pakistan (SSP) - became a permanent institution—under the Ministry of Food and Agriculture. The Soil Survey of Pakistan has surveyed about 715,000 square kilometres of land, covering 81% of the total area of the country (including the Federally Administered Tribal Areas, the Northern Areas and Azad Kashmir). The surveyed area is representative of all those parts of the country that are important for agriculture.

The inventory consists of 55 reconnaissance soil surveys and five integrated soil and vegetation reports, along with maps of 'Land Forms', 'Soils', 'Land Capability' and 'Present Land Use/Natural Vegetation' at 1:125,000 or 1:250,000 scale, and of Generalized (Agricultural) Development Potential' at 1:750,000 scale. The reconnaissance reports provide basic data on soils for agricultural development planning and rational land use to ensure that this resource is conserved while agricultural production is maximized. The integrated survey reports provide data on soils as well as on natural vegetation to guide the development and conservation of rangelands. All these reports have been distributed among prospective users in various national, provincial, semi-government as well as non-governmental organizations involved in the planning of development projects. In addition, the Soil Survey of Pakistan has been engaged in semi-detailed soil surveys of areas under important forest plantations, livestock farms and soil conservation projects, covering over 700,000 hectares. These reports can be used in the planning and execution of development projects in these areas. Detailed soil surveys of some important agricultural areas of the country have also been made to guide in the planning of intensive agricultural development. About 320,000 hectares of land have been covered in different parts of Pakistan, and mainly in the Peshawar, Multan, Hyderabad and Nawabshah Districts. This information, in the form of over 300 reports along with relevant maps at the village/watercourse-command level, has been distributed among various agricultural organizations and enlightened farmers to help in the adoption of appropriate measures to improve and conserve agricultural land, and increase agricultural production. Almost all important agricultural research farms/stations of the country have also been surveyed in detail to facilitate the application of agricultural research to the type of soil cultivated by the farmer. An area of about 5,000 hectares has been covered through these surveys.

LAND CLASSIFICATION

Soil Survey of Pakistan (SSP) evaluated the soils of the surveyed area of Pakistan for sustained production of common and special agricultural crops, as well as their potential for forestry or range development. For this evaluation, the data on soils was integrated with climatic, hydrological, plant and other relevant information.

About 750 different kinds of identified soils were then grouped into eight Land Capability classes (Class I to Class VIII) according to their agricultural potential or relative suitability for sustained agricultural use.

The first four classes (I to IV) are meant for arable use and the last four (V to VIII) for non-arable use i.e., for forestry and range. The Land Capability classification is primarily based on the relative degree, or severity, of limitations of a particular piece of land for agricultural use.

- Class I: Includes soils with no limitations for general arable use (very good agricultural land
- Class II: Includes those with minor limitations under (good agricultural land).
- Class III: Includes those with a moderate degree of limitations (moderate agricultural land)
- Class IV: Includes those having severe limitations (poor or marginal agricultural land).

Classes V – VIII: Include soils that are rated for forestry or range.

- Class V: has soils with minor or no limitations for forestry or range development (good forest or rangeland)
- Class VI: soils having a moderate degree of limitations (moderate forest or rangeland);
- Class VII: for soils having severe limitations are grouped (poor forest or rangeland)
- Class VIII: includes soils which have no potential for any type of agriculture, including forestry and range, (agriculturally unproductive or non-agricultural land).

The Land Capability classification described above also ranks soils according to their capacity to respond to improved management.

Soils placed in Class I are generally very responsive to high inputs of water, improved seed, fertilizers, labor, etc., and also to improved management techniques, while the lower classes have correspondingly decreasing response to inputs and management. Consequently, each Land Capability class/sub-class has a specific set of requirements for land use along with management practices, which would ensure optimal utilization as well as conservation of this resource. These requirements as well as the appropriate measures to offset or minimize the relative limitations are discussed in the soil survey reports.

LAND DEGRADATION

The present use of land is not quite in accordance with its potential. In fact, at present there is no organization in the country responsible for coordinating and monitoring the use of land according to its potential. This makes the quantitative assessment of the impact of land misuse in Pakistan extremely difficult. Only some generalized examples of misuse can, therefore, be quoted. Present land use in the country is based either on the opportunity and economic status or the socio-economic needs of the user. While much land on the steep slopes of mountains—suitable only for forestry or rangeland—has been subjected to ploughing in order to meet the food requirements of the population, a significant portion of good and very good arable land in the Indus plains remains under irrigated forests or is used for non-agricultural purposes. Extensive areas in the Thal and Thar have been overgrazed and are now gravely threatened by desertification. Poor use of soil resources is emphasized when efforts are made to bring marginal or non-agricultural land into arable use, at the expense of large tracts of potential arable land in the Indus plains that remain under-utilized primarily because of water and economic

constraints created by the diversion of resources to relatively unimportant land. Not only are there imbalances between current and potential use of land, but also there are problems in crop planning for areas with high agricultural value. Consequently, land optimality suitable for one crop is used for growing a less suitable one. A good example is how fine basmati rice is generally cultivated on well-drained loamy soils of Northern Punjab, when these soils are really ideal for the cultivation of maize, sunflower, groundnut and pulses. Rice continues to be cultivated, partly because of climatic suitability, and partly because it brings a higher return.

Agriculture is the only sector which is entirely dependent on the quality of natural resources for sustaining higher productivity. Farooq et al 2008 concluded in a study on natural resources degradation and poverty index that those who exploited these resources for the development of the nation (i.e. the farmers), they themselves are now more suffering from vagaries of nature like droughts, disease epidemics, low agricultural productivity and poor standard of living, all indications of poverty. They will remain operating in low input – low output domains with low productivity, low efficiencies and sustained poverty impacts. Moreover, they will remain in this poverty trap until the effective measures for the rehabilitation, regeneration and conservation of natural resources are implemented. A more serious dimension of the issue is that these actual sufferers are not realising the severity of the issue in its true spirit, while the research and development institutions in public, private and NGOs working for the natural resources rehabilitation, regeneration, protection and conservation are operating under top-down approach. It is strange that these organizations are working for the farmers, who are real custodians of these natural resources and most affected by the poverty and productivity consequences, but are least consulted during planning and implementation. In other words, they are least empowered in planning and implementation. Farmer active involvement is also desired because evidence shows that many technological interventions were abandoned by the farmers after the withdrawal of institutional inputs/backup. The primary objective of this paper is to sensitize the policy makers and development planners to create awareness and practice partnership with due empowerment in development planning and implementation of plans and projects pertaining to natural resources conservation.

Besides the economic need of the local people, this mismatch is also a result of the general recommendations made by agricultural research and extension organizations on cropping and management practices. Such recommendations are usually worked out on a particular kind of soil under a specific set of ecological conditions at an experimental farm, but are offered for general use on all kinds of soils in varying environments. The need for an agency responsible for coordination between agricultural research and extension services is one of the reasons behind the improper or irrational use of land.

In addition, specific infrastructure developments in certain areas have had an adverse impact on cropping patterns. An example is the setting up of sugar mills in the Thal and the consequent large-scale cultivation of sugar cane on sandy soils; this has aggravated the water logging problem in the area. To assist in rational land use through a more judicious application of agricultural research, the Soil Survey of Pakistan carried out a detailed soil survey of all important agricultural research farms. It is currently collaborating with various agricultural organizations in the selection and characterization of soils for agronomic experiments. In addition, through the Transfer of Soil Technology to Agriculture Departments scheme, training was imparted to provincial agriculture extension staff. This will help them achieve the following:

- Identify various types of soils in the field
- Appraise the soil for its potential and for its inherent limitations to different kinds of agricultural use
- Adopt appropriate soil management techniques to overcome relative limitations; and assist the farmer in obtaining the maximum output from the land while ensuring soil conservation for posterity.

The training program was carried out in 14 districts: Sheikhupura, Gujranwala, Okara, Sahiwal, Sargodha and Rahimyar Khan in the Punjab; Hyderabad, Nawabshah, Sanghar and Tharparker in Sindh; Peshawar, Mardan and Swat in the NWFP and Lasbela in Balochistan. About 2,700 members

of the technical staff of the provincial Agriculture Departments, including over 800 officers holding supervisory or executive positions, have benefited from the training program. These trainings build capacity of the extension sevices to better guide farming communities on the importance of soil testing and better soil nutrient management.

CHARACTERIZATION OF LAND DEGRADATION IN RELATIONSHIP TO AGRICULTURE

Agro-ecological zoning:

Upon reviewing the available literature on physiography, climate, soil land use and other factors, the agriculture lands of Pakistan are categorized into twelve agro-ecological zones (Table 1).

Table 1: Agro-Ecological Zones of Pakistan

Sr. No.	Name of the Zone	Geographical Coverage	Soil Types	Major Crops
1.	Indus delta	Thatta, Badin	Clayey and Silty	Rice, Pulses, Sugarcane, Berseem, Banana
2.	Southern Irrigated Plains	Hyderabad, Sanghar, Dadu, Khairpur, Larkana, Sukkur, R.Y. Khan, Shikarpur, Jacobabad	Calcareous, Loamy, Silty, Clayey and Sandy	Cotton, Wheat, Rice, Sugarcane, Mustard, Sorghum, Berseem
3.	Sandy Desert (a)	Tharparkar, Nawabshah, Bahawalpur, Nodero Feroz, Mirpur Khas, Cholistan	Sandy, Clayey and Loamy	Guar, Millet, Wheat, Castor
4.	Sandy Desert (b)	Muzaffargarh, Layyah, Sargodha, Khushab	Calcarious, Sandy, Loamy	Gram, Wheat, Cotton, Guar, Sugarcane, Millet
5.	Northern Irrigated Plains (a)	Bahawalnagar, Multan, Khanewal,, Lodhran, Vehari, Sahiwal, Pakpattan, Okara, Lahore, Kasur, T.T. Singh, Faisalabad, Jhang, Sheikhupura, Gujranwala, Hafizabad	Sandy, Clayey, Calcareous, Silt-loam	Wheat, Cotton, Millet, Sugarcane, Maize, Berseem, Citrus, Mango, Melons, Oilseeds
6.	Northern Irrigated Plains (b)	Peshawar, Mardan, Charsadda, Nowshehra, Swabi	Clayey, Moderately Calcareous	Sugarcane, Maize, Gram, Tobacco, Wheat, Millet, Berseem, Groundnut, Sugar beet, Pears, Plum
7.	Barani Lands	Bannu, Mianwali, Attock, Rawalpindi, Jehlum, Gujrat, Sialkot, Mandi Baha-ud-din, Lakki Marwat, Islamabad, Bhakkar, Chakwal, Narowal	Silt loam, Silty clay loam, Clay loam	Wheat, Millet, Maize, Rice, Oilseeds, Pulses, Fodder crops
8.	Wet Mountains	Abbotabad, Hazar, Mansehra, Kohistan, Haripur, Battagram	Silt loam, Silty clays	Maize, Rice, Wheat, Apples
9.	Northern Dry Mountains	Chitral, Dir, Swat, Malakand, FATA, Bunair	Clayey, non-Calcareous and acidic (above 2100 altitude) Calcareous at lower altitude	Maize, Wheat, Rice
10.	Western Dry Mountains	Kohat, Karak, Tank, Zhob, Loralai, Kalat, Sibbi, Quetta, Kachhi, Pishin, Killa Abdullah, Nasirabad, Kohlu, Bolan, Tamboo, Jafarabad, Jhal Magsi, Musakhail, Burkhan, Ziarat, Kila Saifullah, Dera Bugti, Mastung	Calcareous loamy	Wheat, Maize, Apples, Peaches, Plums, Apricots, Grapes
11.	Dry Western Plateau	Kharan, Awaran, Chagai, Lasbella, Karachi, Mekran, Turbat, Khuzdar, Gwadar, Panjgoor	Strongly Calcareous, Silt loams	Wheat, Sorghum, Millet, Melons
12.	Sulaiman Piedmont	D.I. Khan, D.G. Khan, Rajanpur	Loamy, Clayey, Strongly Calcareous	Wheat, Sorghum, Millet, Gram, Mustard, Rice

Source: SSD-PSD-PARC (1980) and PARC (1995).

FORMS AND TYPES OF LAND DEGRADATION

There is a serious problem of desertification in many parts of the country. 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 are silting up, thus reducing the capacity of power generation and availability of irrigation water. Barani lands are subjected to heavy soil erosion, primarily due to improper land use by crop cultivation, livestock grazing and illegal removal of vegetation cover (Ashraf, 1993).

Deserts have acute problems of shifting sand dunes and salinity. The irrigated areas are infested with the twin-menace of water logging and salinity. Because of mis-management of Suleiman Rod Kohi areas, there is substantial damage to crops and property by flash floods. Underground water resources in western dry mountains of Balochistan are shrinking due to very little recharge and overexploitation of the meager quantity of water for horticulture and crop cultivation. The productivity of rangelands is hampered by heavy livestock pressure. The arid coastal strips and mangrove areas are under increased environmental stress caused by reduced fresh water flows, sewage and industrial pollution and overexploitation. The following are the key issues related to desertification:

- Water erosion
- Wind erosion
- Depletion of soil fertility
- Deforestation
- Livestock Grazing Pressure
- Loss of Biodiversity
- Water logging and Salinity
- Drought and Flooding
- Socio-economic constraints
- Soil Pans
- Soil Nutrient Degradation

1. **Water erosion:** The soils in the Indus basin are new and undeveloped and the mountains surrounding the area have some of the world's steepest and largest slopes. Intense summer rainfalls, along with melting snow in high mountains contribute to the soil erosion hazards. Land use practices, vegetation cover, soil type and structures are other major factors related to soil and water erosion. In the 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 arable crops on steep slopes. About 11 million hectares are affected by water erosion.

   Sedimentation of canal irrigation system decreases water and land use efficiency. Some 40 million tons of soils are brought into the Indus basin each year, which shortens the life span of major reservoirs and reduces their efficiency. The upstream riverside infrastructure is destroyed and top soil is washed away declining productivity of the area. In downstream, the sedimentation reduces the efficiency of hydropower generation and irrigation systems.

2. **Wind erosion:** Land degradation by wind erosion is quite common in the sandy deserts of Thal, Cholistan, Tharparkar and sandy areas along Mekran Coast. Erosion is significant in areas around habitations and watering points trampled by livestock. Here, the major degrading factor is the over-exploitation of rangelands for fuel-wood cutting and livestock grazing. The global impact of wind erosion is prevalent in areas where sand dunes are leveled for irrigated cropping. These areas have assumed the form of 0.5 meters to 4-meter-high moving sand dunes, posing danger on cultivated land and infrastructure.

   Some 3-5 million hectares are affected by wind erosion. The amount of soil removed by wind is about 28% of total soil loss. High velocity wind storms cause severe movement of sand dunes,

depositing thick layers of sand on roads, railway tracks and croplands, ultimately threatening village inhabitants.

3. **Deforestation:** There is only 5.2% area under forests, which is too low to meet the environmental, as well as the socio-economic needs of the country. Due to deforestation, forest cover is shrinking by 3.1% annually and woody biomass, by 5% annually. Natural vegetation reduces sedimentation in water reservoirs and stabilizes sand dunes (Noor, 1994).Mangrove forests protect the port of Karachi against wave action and act as nursery for the existing shrimps. Every major type of forest or protective land cover in Pakistan has suffered heavily in the recent years from indiscriminate wood cutting, overgrazing, poor management and ecological changes brought about by human interference. This increases desertification and aggravates erosion and silting of reservoirs and biological defenses against water logging and salinity. The ability to resist soil erosion caused by monsoon rains is largely dependent on vegetation and vigor of vegetation at ground level. Soil erosion increases on degraded grazing land with sparse vegetation cover, which leads to siltation of rivers and channels. Soil fertility declines due to removal of top soil resulting in low production of forage, fodder, fuel wood, timber and grains. Soil erosion in the watershed areas of rivers increases sedimentation load, which reduces the storage capacity of dams.

4. **Livestock Grazing Pressure:** Free grazing of livestock is extremely destructive to forest and vegetation cover. In Balochistan, livestock production primarily depends upon rangelands. Sheep and goats obtain about 60% of their feed from rangelands (Zaffaruddin, 1977) while in Balochistan, 90% of the required livestock feed is provided by rangelands (FAO, 1983).With the increase in livestock population there is heavy pressure on natural vegetation. During periods of feed scarcity, thousands of cattle, sheep and goats depend on fodder plants, which are lopped off the main stem. Unsystematic livestock grazing reduces the productivity of rangelands due to soil compaction, devegetation of fragile slopes, destruction of terraces and selective destruction of growing trees and shrubs. As economy in desert regions is pastoral, it affects both livelihoods of the desert dwellers as well as influences the fragile environment.

5. **Loss of Biodiversity:** Due to the ever-increasing human and livestock population there is enormous pressure on natural vegetation in almost every agro-ecological region of the country. Overgrazing of rangelands has extensively decreased the carrying capacity. Some areas have also been affected by water logging and salinity damaging the natural flora. Aridity and prolonged drought in arid lands have affected the vegetation cover in these areas. All these factors have contributed towards the loss of biodiversity in various regions of the country. As a result of natural habitat degradation and illegal hunting, 31 species of mammals, 20 species of birds and 5 species of reptiles are listed as endangered species in the country.

6. **Water logging and Salinity:** The major factor contributing to water logging in cultivated areas is excessive percolation from the canal system, which builds up the ground water level. Human activities can also aggravate water logging problems through actions which include the following:

    - cultivation of high delta crops on highly or moderately permeable soils
    - obstruction of natural drainage channels through construction of buildings and roads
    - improper alignment and poor maintenance of artificial open drainage system
    - inefficient disposal of excess rain water, etc.

    Total waterlogged area with water table depth of 5-10 feet in Pakistan is about 11 million hectares. Salinity and sodicity are associated with irrigation but these also occur as a consequence of soil formation process over the centuries. In Pakistan, the soils affected by various types of salinity and sodicity constitute 5.328 million hectares, half of it in Punjab and 40% in Sindh and 9% in Balochistan province (Mian and Mirza, 1993). Water logging, salinity and sodicity have reduced the drainage capacity of the soils resulting in lower soil fertility, decline in crop yields and loss of biodiversity (Zia and Baig. 1986).

7. **Drought and Flooding:** Drought is a temporary feature caused by anomalies in the usual climate of the region. It occurs in virtually all-climatic conditions, but with higher frequency and probability in the arid and semi-arid regions. Periodic droughts are seen as a major cause

of desertification in several desert areas of Pakistan. Recently, the provinces of Balochistan, Sindh and southern Punjab have been severely impaired due to prolonged spells of drought for the last 3 years. It is estimated that 2.2 million people and 7.2 million heads of livestock have been adversely affected. The effects and impacts of drought in fragile eco-systems assume serious proportions of land due to misuse of marginal areas, unwise land use practices and overexploitation of natural resources. Adverse effects of drought on human activity usually last for many years.

Flood occurrence could be an occasional or regular feature of the region. Being an arid to semi-arid country, floods are usually caused by excessive precipitation particularly during the monsoon season due to weather and climatic disturbance. Floods in 1973 and 1992 caused severe damage to the national economy resulting in land degradation and loss of biodiversity. Floods prohibit cultivation in summer season, destroy farm houses and other facilities and bury fertile top soil under relatively infertile sediments.

8. **Soil Pans:** Most of the cultivated land of Pakistan has remained under the traditional country plough for many decades. The plough penetrates the soil down to a fixed depth of 7-8 centimeters. Continuous tillage to the same depth has resulted in the formation of a relatively dense layer, referred to as the plough pan, in a large portion of the cultivated area. The plough pan, which lies at a depth of 8-20 centimeters, is specially pronounced in soils which are high in silt. It acts as a weak barrier to the penetration of water and plant roots; irrigation water accumulates just above this pan and enters the subsoil only after creating temporary ponding conditions; plant roots tend to spread horizontally above the pan. These conditions inhibit or adversely affect crop growth, especially during the initial stages. A plough pan is of much greater significance in the sloping areas of the Pothowar, where most of the soils are silty and farming with the country plough is the general trend. The resulting reduced permeability of the soil may be regarded as one of the major factors responsible for high run-off after the rains with increased soil erosion. The area where plough pans are significantly affecting crop yields is estimated to be quite large, even though it cannot be accurately measured in quantitative terms as this would require more detailed soil data. The recent introduction of deep ploughing and chiseling have offered a solution to this problem. But these techniques are being introduced indiscriminately as normal tillage operations, as a way of improving crop yields. This may have a detrimental effect on soils with a good subsoil structure, since it may lead to structural deterioration and reduced productivity after an initial two to three years of high yields.

   In addition to plough pans, a naturally formed, weakly-cemented layer of lime-rich silty material is almost invariably encountered within a 1.5-metre depth in the Potowar and in the old river terraces in the Indus plains. This layer, recognized as the kankarzone, is slowly permeable; it restricts the infiltration of water and plant roots and checks leaching of salts from the soil surface to lower depths. Water accumulating just above this layer for significant periods, after irrigation or rain, affects crops adversely, especially when they are near maturity leading to decreased crop yields. Soil underlying the kankarzone is generally high in silt and only slowly permeable, a condition which favors the accumulation of lime and soluble salts just above it.

9. **Soil Nutrient Loss:** A significant portion of cultivated soils are low in retained important plant nutrients. This nutrient deficiency, mainly of nitrogen, phosphorus, potassium, sulphur, zinc, copper, iron and manganese, has been indicated by various fertilizer experiments conducted on soils in different parts of the country. The problem is particularly severe in the case of irrigated sandy soils, moderate in the case of irrigated loamy soils of old river terraces, and of a minor degree in other soils. The main causes of soil nutrient depletion are:

    1. Leaching of nutrients by irrigation water (sandy soils and the more permeable loamy soils are commonly over-irrigated), and by rain in high rainfall areas.

    2. Continuous cultivation of soils over long periods, with almost unchanged cropping patterns dominated by exhaustive crops like wheat, sorghum, maize, cotton, sugar cane and mustard.

    3. A hot and arid climate in many parts of the country, leading to high decomposition rates of organic matter and a net loss in the organic content of soils.

4. Inadequate addition of organic fertilizers or green manure, resulting in a constant decrease in the organic content of soils.

5. Continued use of single-nutrient fertilizers (like urea) which has lead to increased extraction and hence deficiency of other plant nutrients from the soil.

Since regular surveys to assess the nutrient status of soils have not been conducted, it is not possible to quantify the problem of soil nutrient degradation.

Surface Slaking or crusting: A large proportion of soils in the country is mainly made up of silt or very fine sand. While medium to coarse sand and clay particles (by virtue of their general occurrence as aggregates) are relatively heavy and difficult for the water to transport, silt and very fine sand particles, occurring as isolates and being lighter in weight, are easily water-borne. When the topsoil is dominated by the silt and fine sand particles, its surface material tends to flow with rain or irrigation water, and is deposited as a thin crust on the soil surface, subsequently sealing it altogether – a phenomenon called surface slaking. Since this crust has almost no clay, it seldom cracks on drying and generally keeps the surface completely sealed unless broken manually by proper tillage implements. Its major impact is that it restricts the infiltration of irrigation or rainwater into the soil, and blocks air and temperature exchange between the soil and the atmosphere, severely hampering plant growth.

Surface slaking in silty soils is further favored by the low organic content and the high percentage of exchangeable sodium in the topsoil; in the latter condition, even soils having low silt and high clay contents are affected by surface slaking, since sodium facilitates the dispersion of clay aggregates. A similar situation develops when soils are irrigated with poor quality groundwater with high SAR values. Crusts formed by sodic water restrict air, water and temperature exchange with the soil, which is detrimental to germinating seeds and sprouting plants. The problem of surface slaking or crusting is widespread because of the extensive occurrence of silty soils, and is understood to affect crop production considerably when preventive measures are not adopted. It is, however, difficult to quantify the problem until detailed soil surveys are carried out.

DEALING WITH LAND DEGRADATION POLICY ENVIRONMENT IN THE COUNTRY

Priority status of dealing with land degradation in the national development plan

The programprogram on combating desertification focuses, inter alia, on the following areas:

- Afforestation/agro- forestry in degraded areas
- Improved crop production in dry lands
- Improved range/livestock feeding and management
- Soil and water conservation, water harvesting and increased water use efficiency
- Rehabilitation and reclamation of saline/sodic soils
- Improvement of drainage and on-farm management, production and promotion of horticultural crops
- Conserving biodiversity.

The National Action Plan (NAP) also addresses the effects and mitigation of droughts in Pakistan.

INSTITUTIONS DEALING WITH LAND DEGRADATION (GOVERNMENT AGENCIES), THEIR RESPONSIBILITIES AND CAPACITY

The implementation of the National Action Plan requires inter-agency cooperation for joint programming, planning and, in some cases, joint implementation and day-to-day operational

coordination. For example, range improvement, development and management cannot be carried out without joint programming of the Departments of forestry, livestock, agriculture and soil survey department, in addition to the involvement of ranchers and CBOs.

In order to focus on the conservation and sustainable use of natural resources in general, and to enable them to participate in the implementation of the National Action Plan in particular Building the capacities, it is essential to build the capacities and review the mandate of the of the following organizations:

Federal Organizations

1. Pakistan Agricultural Research Council
2. Pakistan Council for Research in Water Resources
3. Water and Power Development Authority and its institute for Water logging and Salinity Research
4. Arid Zone Research Centre, Quetta and its institutes
5. Space and Upper Atmosphere Research Commission
6. Soil Survey of Pakistan
7. Pakistan Forest Institute
8. Meteorological Department
9. Marine Fisheries Department
10. National Council for the Conservation of Wildlife
11. National Institute of Oceanography
12. Zoological Survey Department

Provincial and Local Organizations

1. Universities of Agriculture, including University of Arid Agriculture
2. Agricultural Research Institutes/Stations in arid/semi arid areas
3. Agency for Barani Area Development, Punjab
4. Fisheries Research Institutes/Stations
5. Environmental Protection Agencies
6. Forestry Research Institutes/Stations/Divisions
7. Sindh Arid Zone Development Authority
8. Cholistan Institute of Desert Studies
9. Cholistan Development Authority
10. Coastal Development Authority (Sindh)
11. Wildlife Departments/Boards

Non Gvernmental and Community Based Organizations

1. International Union for Conservation of Natural Resources (IUCN)
2. Sustainable Development Policy Institute (SDPI)
3. Society for Conservation and Protection Environment (SCOPE)

4. Agha Khan Rural Support Program (AKRSP)
5. Pakistan Institute for Environment and Development Action Research (PIEDAR)
6. Rural Development Foundation

'The National Action Plan for Combating Desertification' helped to identify gaps in capacity for the planning of sectoral projects. Some of the gaps in capacity to integrate desertification with planning for various sectors are listed hereunder:

1. Lack of an appropriate planning process for the preparation of project documents, i.e. planning phases like project identification, formulation and appraisal are not normally followed.
2. Insufficient participation of experts especially in multi-dimensional and integrated projects.
3. Hardly any resources are made available to constitute missions for identification, formulation and appraisal phases of project planning.
4. Insufficient participation of beneficiaries in the planning process because the experts involved in project planning have strong assumption that they are the best judges of project interventions.
5. PC-I has to be followed strictly and process of modification is extremely difficult. The rigid approach is one of the major limitations for effective implementation of the development projects.
6. Re-planning, fixing and re-fixing of targets based on the real-life situation is a difficult task within the rigid framework of PC-I.
7. The delay in project funding and inappropriate costs results in delays in completion of projects. Normally the project duration exceeds the planned duration and completion normally happens at a higher cost.
8. Experts normally involved in the preparation of project documents are those who are not directly involved in conducting appraisals with the stakeholders. Even in certain cases they do not have the capacity to conduct participatory appraisals and planning to identify problems and documentation of options for the development of solutions.
9. Serious gaps exist in capacity for participatory appraisals, planning and formulation of projects with concerns related to the environment, desertification and global warming.

Existing policies:

Objectives:

The National Conservation Strategy has three overriding objectives:

- Conservation of natural resources
- Sustainable development,
- Improved efficiency in the use and management of resources.

Reaching these goals depends in turn on three operating principles:

- Achieving greater public partnership in development and management
- Merging environment and economics in decision making
- Focusing on durable improvements in the quality of life of Pakistanis.

Agricultural policies influencing land use patterns:

Rainfed Areas

Policies

1. Halt over-use of prime soil/ resources.
2. Check/reserve soil/land degradation processes.
3. Manage water run-off/shortage to prevent soil erosion.
4. Restore and improve fertility/structure of degraded soils.
5. Optimize land use.

Measures

1. Develop soil and water conservation plans for each sub-catchments area.
2. Protect, under permanent vegetation cover, high-risk erosion areas.
3. Use integrated engineering, cultural, and biological soil/water conservation solutions.
4. Adopt ecologically compatible cropping systems.
5. Encourage adoption of effective soil and water conservation practices.

Irrigated Areas

Polices

1. Halt/control salinity/sodality, waterlogging, and soil structure deterioration problems.
2. Prevent/control soil degradation processes.

Measures

3. Identify and demarcate areas requiring high priority regeneration.
4. Subsidize gypsum supplies to farmers for reclaiming salt affected soils.
5. Correct sodality and structure deterioration in about half the area irrigated by sodic tube-well water.
6. Encourage construction of open farm drainage systems and install shallow tube-wells/tile drains as appropriate.
7. Develop fish ponds in appropriate low-lying areas.
8. Strengthen existing arid zone research institutes.
9. Promote land leveling to increase water-use efficiencies.

Cultivable Waste Lands

Polices

Use cultivable waste areas, based on land capability data and availability of water.

Measures

1. Develop land use plans for cultivable waste areas.
2. Use land in sweet water areas to grow ecologically compatible crops.
3. Grow salt-tolerant grasses, shrubs and trees in saline groundwater areas wherever feasible.

Rangelands

Polices

1. Develop systems for effective periodic closure of rangelands, to rehabilitate them and ensure sustainable livelihoods for range dwellers.
2. Make investment in the restoration of community-based management systems for communal rangelands the center piece of government support program programs programs.
3. Selective facilitation of private investment in rangeland development for commercially oriented livestock export.

Measures

1. Enforce existing land reform laws where absentee holdings of large tracts of rangeland are an impediment to proper management.
2. Consider the formalization of de facto local grazing on government-owned rangelands, not under any management scheme, by grant of range licenses to whole communities.
3. In tribal areas, develop and undertake community-based revenue settlement for rangelands, involving the negotiation, recognition, and formalization of user rights and concessions, and issue rangeland management licenses to the community as a whole.
4. Encourage the formation of Livestock Associations under the umbrella of existing law (e.g., Punjab Livestock Associations Ordinance, 1979).
5. Upgrade departmental and multi-sectoral extension services, but keep programprogramsprograms cost-effective by focusing on educational and motivational inputs and use of locally available materials.
6. Provide technical and related advice on community-based management systems.
7. Make public-sector investments in the form of critical interventions, such as development of watering points, selective range re-seeding, and emergency provision of palletized fodder, and link them to progress in community organization for self-help.
8. Help herders reduce stock levels significantly during drought periods to match the rangeland's lowered carrying capacity, especially by expanding the proposed fringe feedlots scheme in the private sector.
9. Provide compensation for income loss during drought destocking or closure in the form of alternate interim activity for the drought/closure duration, but linked to the main program and of lasting benefit (e.g., construction of veterinary hospital with the herders providing manual labour).
10. Time any financial support to herding system (e.g., loans for improvement of breeding stock) with range re-opening.
11. Undertake the above programprogramsprograms on a small-scale pilot and demonstration basis for a possible period of five years to monitor and evaluate results, and to follow up with extensive projects.

Forest Management

Policies

1. Give top priority to recognizing the vital ecological services provided by watershed, reverie, and mangrove forests, and to their maintenance.
2. Use forest resources of sustainable yields, and in most cases, resources of maximum sustainability yields, thus promoting vigorous growth of younger stocks in order to meet conservation criteria, and local and national demands.

3. Preserve and manage, on a representative basis, some old forests to maintain the bank of biodiversity.
4. Concentrate on statement management in forest areas that are vital to public interest. In order to be effective, undertake an interdepartmental program to provide alternative sustainable livelihoods to the affected locals.
5. Accelerate the current efforts to promote afforestation on critical watersheds under private ownership.
6. Upgrade the program for promoting plantations (on marginal agricultural lands, along field boundaries, etc.) to meet the rising domestic demand for timber and related products while enhancing natural resource values.

Measures

1. Increase awareness, and thereby muster political support for sustainable development of forestry resources.
2. Revise forestry legislations and forest policy directives to help meet essential ecological requirements, given socioeconomic realities and potentials.
3. Use satellite imagery in conjunction with ground trotting both to assess and monitor earth degradation process in critical ecosystems and to identify priority areas for new planting.
4. Conduct multi-disciplinary problem-oriented research for each agro-sylvo-pastoral system in order to generate technology packages for end-users.
5. Prepare strategic action plans in the light of physical and socio-economic findings and available resources.
6. Strengthen the forest departments to achieve public objectives in the 0.5 million hectares of state hill forests classed as closed-cover conifers.
7. Improve administrative arrangements of the delivery of multicultural services and advice to enable sustainable livelihoods for populations residing in and around hill forests.
8. Accelerate watershed management programprogramsprograms in all other hill forest areas by shifting towards an integrated and facilitative role for departments.
9. Promote the private sector to take the leading role in irrigated planting and farm forestry.
10. Introduce economic guarantees in support of private farm forestry and related initiatives in the case of cultivable wasteland.
11. Demonstrate the benefits of arid, un-irrigated area plantations.
12. Preserve genetic resources and biodiversity by selective creation of strict ecological reserves, declared as such.
13. Restructure forestry extension by strengthening social forestry extension circles and upgrading forestry packages of agriculture extension agents, as well as creating joint existence cadres according to the requirements of disseminating the technology packages identifies for each agro-ecological zone/sub-zone.
14. Create forestry products' marketing boards in provinces, with mandates both to provide accurate market forecasts to planters and to promote steady demands for these long gestation products, which entail timely investments by the wood pulp and paper industries and other major market outlets.
15. Promote the role of women in farm and watershed forestry with special emphasis on removing social inhibitions, promoting information exchange, and empowerment of women, entailing decision making and user rights.

Previous and existing projects dealing with land degradation

Pakistan Council of Research on Water Resources

1. Desertification assessment and mapping of the Cholistan Desert.
2. Rain water harvesting in Cholistan.
3. Tree plantation by using rain water and ground saline water.
4. Sand dune fixation and stabilization.
5. Reclamation of desertified land by the introduction of Jojoba, Atriplex.
6. Design and preparation of sand trappers.

Pakistan Agricultural Research Council

1. Development of desert reclamation techniques by planting of drought tolerant plants with rainwater harvesting, pitcher irrigation and drip irrigation.
2. Establishment of shelterbelts and windbreaks for protecting crops and soil conservation.
3. Introduction and propagation of promising arid land plants like saltbush, Salicornia, Tamarix, Vetiver grass, Jojoba.
4. Agro forestry systems of raising trees in conjunction with crops.
5. Reclamation of saline and waterlogged areas by planting salt tolerant trees and shrubs.
6. Pumping water using renewable energy.
7. Soil and water conservation.
8. Ground water management.
9. Irrigation efficiency and water management.

University of Agriculture, Faisalabad

1. Reclamation of saline areas.
2. Agency for Barani Areas Development (ABAD), Rawalpindi
3. Soil and water conservation in rainfed areas.
4. Afforestation and range development.
5. Water resources development.
6. Women training and extension.
7. Farm to market roads.
8. On-farm water management.
9. Micro enterprise development.
10. Rural infrastructure development.

Arid Zone Research Institute (AZRI), Bahawalpur

1. Arid horticulture.
2. Establishment of grasses on sand dunes.
3. Medicinal plants in arid areas.

Cholistan Development Authority, Bahawalpur

1. Colonization and allotment of Government land.
2. Development of water resources and surveys for sweet ground water.
3. Development of communication facilities.
4. Drought relief and management.

Sindh Arid Zone Development Authority, Karachi

1. Development of water resources.
2. Communication facilities.
3. Agricultural and livestock development and relief and rehabilitate.

Water and Power Development Authority (WAPDA)

Salinity control and reclamation programs

Cholistan Institute of Desert Studies (CHIDS), Islamia University, Bahawalpur

1. Selection and propagation of salt tolerant and drought resistant shrubs, trees and grasses.
2. Studies on desert plants with emphasis on their morphogenic and ethno botanical characters and medicinal value.
3. Studies on nomadic lifestyle and socio-economic aspects of the desert dwellers.

Pakistan Forest Institute (PFI), Peshawar

Dry land Afforestation, agro forestry, watershed/rangeland development and management.

Soil Survey of Pakistan, Lahore

1. Land capability classification.
2. Soil-Vegetation Surveys.

Punjab Forestry Research Institute Gatwala, Faisalabad

Agro forestry, Afforestation.

Punjab Forest Department

Forestry Sector Development Project.

NWFP Forest Department

Forestry Sector Development Project.

Non-Governmental Organizations (NGOs)

1. International Union for Conservation of Natural Resources (IUCN)
2. Sustainable Development Policy Institute (SDPI)
3. Society for Conservation and Protection Environment (SCOPE)
4. Agha Khan Rural Support Program (AKRSP)
5. Pakistan Institute for Environment and Development Action Research (PIEDAR)

6. Rural Development Foundation
    - Objectives and scale of the project
    - Impact of the project
    - Sustainability and potential for scaling-out

AVAILABLE TECHNOLOGIES TO DEAL WITH LAND DEGRADATION

The approaches used to control water logging and salinity include restoration of soil health through gypsum application. This approach is capital intensive and requires heavy irrigations. The more successfully used (on more than 3 million ha of salt affected lands) technologies were salt tolerant varieties of crops like wheat, cotton, barley, sorghum, millet and tree species like Eucalyptus camaldulensis, Acacias and Tamarix. Salt tolerant shrubs like Atriplex species or other suitable grasses were also extensively tried in rangeland of Balochistan and rainfed Punjab provinces.

The technologies to utilize underground brackish water were validated for crop production by lining the water tank and water channels with gypsum stone and field application of gypsum stone and farm yard manure. This helps release soil micro-nutrients beside alleviating the deteriorating effects of sodium ions on plant growth.

A seed/fertilizer drill for wheat planting has been developed for effective utilization of P by the plants. This technology is suitable for the majority of calcareous alkaline soils of Pakistan.

The Potash Institute of Canada (PPIC) along with PARC, provincial agricultural institutes and fertilizer industry of Pakistan was able to enhance crop response to K by 15-30 percent. Consequently, Murate of Potash (MOP) was introduced for crops and saline sodic and high water table soils. The use of K also helps improve N efficiency and crop quality.

It has been identified that soil conditions in Pakistan tend to be short of available nutrients like Zinc (Zn), Boron (B) and Iron (Fe). The extent of these deficiencies were identified in different cropping systems and through on-farm research recommendations for rice, wheat and cotton crops.

Nitrogen bio-fertilizer, Em-technology and Phosphorus bio-fertilizers were developed for crops including leguminous crops.

In order to conserve water and reduce water logging, the consumptive use of water (CUW) for 19 crops in 6 agro-ecological zones of Pakistan is being managed. Sprinkler and drip irrigation systems were introduced in rainfed ecologies and trickle irrigation systems in areas where water is very scarce such as Balochistan, DG, Khan, Kohat, Bahawalpur and Attock.

The water logging is partly managed through increasing the use of groundwater which helped in increasing evapotranspiration, drawing down the groundwater table and leaching much of the salts down and out of the root zone. The drivers of this revolution were the farmers who installed tubewell and diesel engine to use underground water for increasing their crop yields and incomes.

Promoting efficiency in the use and distribution of water has been achieved to some extent through the On-Farm Water Management (OFWM) Programme, which has been operating in Pakistan since 1976. So far, 21,000 watercourses have been brought under OFWM; another 86,000 remain to be attended. A major achievement of the OFWM Program is that it has worked through Water Users' Associations (WUAs) in an attempt to fully involve the farming community in the construction, renovation, and post –improvement maintenance of watercourses. Members of the WUAs have provided skilled and unskilled labor with technical assistance from the OFWM staff. They have also borne some of the costs involved. Other water management initiatives have included the construction of water storage tanks in mountainous regions, hydra ram water lifting devices, and sprinkler irrigation.

The Mangla Watershed Management Project by the Water and Power Development Authority (WAPDA) built 2,500 silt traps and 350,000 masonry check dams, and planted 5% of the watershed

with grasses and long-rooted trees, resulting in a reduction of siltation from 30 to 7 tons per acre foot of run-off in the Kanshi basin. The project prolonged the life of the Mangla dam to 70 years.

Developed by PARC in collaboration with the International Center for Integrated Mountain Development (ICIMOD), the Sloping Agricultural Land Technology (SALT) for the Himalayan foothills of Pakistan was developed. This technology was aimed at preserving the soil and its fertility.

An integrated land and water-conservation approach has been developed by Pakistan Agricultural Research Council (PARC), by setting up a model in the Pothowar Plateau of northern Punjab at Mungial (near Fatehjang). The area was used according to the land-capability for crops, pasture, fruit trees, and other tree-planting. Except for 4% of total area of grassed waterways of gullies and ponds, the rest of the land was used for production of crops, pastures, orchards, and forest trees. The minimum required land-development operations were carried out, without disturbing or removing the soil. After 10 years, gullies have been completely reclaimed and erosion has been fully eliminated in the area. Harvesting of forest-trees has yielded appreciable wood, a source of handsome return. Fruit trees are continuous sources of income. The model becomes a source of inspiration and confidence for other farmers of the area. By adopting this model, farmers can make best use of degraded land and raise their income reasonably (Zia and Rashid, 1995).

Pakistan Agricultural Research Council (PARC) in collaboration with provincial research and extension system developed zero-tillage wheat sowing and bed planting technologies for the major rice-wheat and cotton-wheat systems of the country. These technologies contributed significantly in improving crop productivity on saline land through resolving germination issues, improving crop-stand establishments, enhancing fertilizer use efficiencies and water resource conservations.

For Barani areas an integrated land use model was developed which helped to identify the technologies related to moisture conservation, increasing copping intensity and sustainable high value crops production. Soil and Water Conservation Research Institute developed low-cost water conservation structure technologies to protect lands from water erosion and to better conserve soil moisture for better crop production in rainfed Pothwar. These technologies are in the up-scaling phase in other watershed management related projects presently under implementation in rainfed areas. Water distribution structures were developed for rod-kohi system agriculture (2 million ha) for flood water diversions, increasing moisture availabilities and combating effects of cyclical droughts.

Rangeland development technologies include micro-catchment water harvesting technologies such as ridge formation for shrubs establishments, V-shape plants rehabilitations structures, fodder reserves development for winter grazing through plantation of drought tolerant shrubs (atriplex and acacia species), reseeding of grasses like Chryso and Symbo species in Balochistan and Punjab provinces. The spread of these rangeland development technologies is still limited and requires planned participatory efforts through community involvements and social mobilization.

CONCLUSIONS:

Pakistan is threatened with desertification and degradation of land. About 68 million hectares of land area lies in fragile regions. The country has a highly complex and diversified agro-ecological and socio-economic set-up. One fourth of the country's land area, which is suitable for intensive agriculture, is seriously subjected to threats of wind and water erosion and the twin menace of water logging and salinity. In Pakistan, land degradation has been worsening due to an absence of effective policy and reluctance in the implementation of certain laws, along with lack of interest on the part of concerned authorities.

There will be neither sustainable development, environmental protection, nor improvement in the climate for future generation, or preservation of the bio-diversity if we do not protect the earth from land degradation and its political, economic and social consequences. In this undertaking government, NGOs, business community and private citizens of the respective regions will have to be partners if they are to combat desertification and drought.

Agriculture has a well established record as an instrument for poverty reduction as well as a leading sector for overall growth in the agriculture-based countries of the world (World Bank, 2007). Concrete efforts to reduce poverty and promote sustainable development, as well as to increase awareness worldwide of the problems of the natural resources degradation and of the solutions, can only help us make the difference for the people living in the marginal dry land areas.

Knowledge Gaps

The sustainable management of a huge, inter-linked and very complex natural resource base is the single most challenging long-term task for natural resource managers in Pakistan. It requires the development of world-class capacity in adaptive management of natural resources, development and management of water resources and in developing new institutional arrangements involving communities in natural resource management. Pakistan needs to build a strong natural, engineering and social scientific cadre capable of working with all users in defining the problem, developing solutions, monitoring, assessing and adjusting. This is a capacity which requires a wide range of disciplines—those necessary for understanding climate change, judicious use of natural resources, causes of land degradation, changes in soil profiles/structures, water quality, sediment management, hydraulics, terrestrial and coastal ecosystems, agronomy, plant physiology, industrial organization, conflict management, politics, economics and financing. It will require an expansive and long-term human resource strategy which will update the skills of the formidable capacity which exists in Pakistan, but will also strengthen the capacity of universities and other scientific and training institutions to produce high-quality applied researchers and to train the next generation of natural resource managers and policy makers.

There is a strong need to understand that the objective circumstances associated with natural resources have been considerably changed. Market forces have influenced the attitudes of communities in such a way that they put a very low premium on collective strategies. Population growth, off-farm orientations and greater differentiation in the capacity to exploit natural resource base among communities have made it difficult to evolve and maintain a collective community stake in managing natural resources. Experience shows that while implementing resource conservation strategies in the rainfed Pothwar and dry mountainous areas of Balochistan that the culture of group actions towards rehabilitation of natural resources for collective gains is very difficult to be revived. It is therefore important to find new functional substitutes for traditional arrangements that can appropriately fit with the present day circumstances. The incorporation of the three elements that includes community stake, local control, and functional knowledge of natural resources into the present resource use systems may help in the rehabilitation and conservation of natural resources. The challenge lies in creating a present-day functional substitute that can promote these key elements and induce communities to protect and develop their natural assets while continuing to use them.

Research implications

Soil and water are important natural resources on which agriculture sector growth and rural livelihood depends. Conserving these vital natural resources is very critical for achieving current and intergenerational food security and high productivity goals. Optimal use of these resource would not only ensure continued availability of the basic human needs for food, fibre and shelter, but also improve the overall ecological environment. The following research focuses are emphasized in the light of the major problems associated with land degradation in the country.

1. Scaling-up the techniques employed for developing low cost water erosion structures at watershed scales
2. Consolidation of research efforts to optimally utilize land water resource in the small dams command areas
3. Formulating soil-specific cropping patterns for providing effective soil cover during the rainy season.

4. Identification of suitable leguminous or green manure crops to improve the organic content of soils and to reduce its erodibility
5. Strengthening specific plant breeding programmes for evolving suitable salt and drought resistant species.
6. Identification and propagation of suitable species to stabilize sand dunes
7. Developing research based recommendations on irrigation scheduling and intensities for the micro climatic regions considering varying soil characteristics
8. Developing specific strategies based on gypsum or salt tolerant plant use for the reclamation of saline and sodic soils.
9. Developing soil type based strategies for using underground saline water resources more appropriately
10. Identification of local plants, adapted to saline and drought conditions with some economic/social value in terms of forage, wood and shade.
11. Evolve low cost construction and strengthening of existing field boundaries and embankments of channels diverting torrent water to the fields in dry mountainous areas of Balochistan.
12. Demonstrating the use of different implements for breaking plough pans and deep ploughing for harvesting rain water.
13. Research on changing the cropping patterns to include crops which add organic matter and nutrients to the soil i.e., leguminous crops like alfalfa, berseem, sesbania and groundnut.
14. Developing the technique of light and short intervals irrigations for different soil types to minimise nutrient loss through leaching.
15. Balanced use of major and micro-nutrients is a very vital area for developing production system specific recommendations
16. Developing irrigation techniques that reduce the formation of surface crusts
17. Socio-economic research on economic impacts of land degradation policies, coping strategies and technological interventions for providing feed back on resources use planning, joint managements, costs and benefit sharing, investments appraisal for re-habilitation, measuring economic pay-offs and institutionalization of successful ventures.

Development implications

Pakistan has been striving to streamline the use of natural resources in a manner to provide a decent living to more than 117 million people, further growing at an annual rate of around 2%. There is an urgency of merging the economic and the environmental in decision making and in the use of economic instruments rather than regulation to control degradations. Various policy documents prepared to conserve natural resources and combat land degradation suggest implementing a series of crosscutting inter-sectoral programmes for implementation in different agro-ecologies of Pakistan. These include -

1. Developing policies to control un-planned expansion of cities and towns on fertile lands, dumping of sewage water and factory effluent on productive lands.
2. Regreening bare slopes, where feasible, through reseeding and replanting with suitable plant species; proper care of growing plants until they are fully established and effective control, thereafter, on grazing particularly by nomadic livestock.
3. Protecting loess terrace remnants from being leveled for cultivation; the remnants along with their side slopes should, where feasible, be replanted to stabilize them.
4. Making mechanical power available to the common farmer for deep ploughing, chiseling and subsoiling where required, and to improve existing cultivated ter races to enhance water absorption and minimise runoff from sloping land.

5. Discouraging the removal of vegetative cover from sandy ridges, especially those located in arid and semi-arid areas, by providing alternative sources of fuel and other basic requirements.
6. Reclaiming saline and saline-sodic soils through the use of gypsum. Heavy irrigation should be used only when a drainage system exists or when natural drainage, permeable substrata, is available. If these conditions cannot be met, biological measures i.e., growing salt tolerant plants should be used.
7. Active guidance and supervision of farmers using tubewell water, by providing timely information e.g., on the quality of their tubewell water, as well as by explaining or demonstrating the consequences of using low-quality water for irrigation.
8. Planting vegetation which could provide surface cover against salts blown by winds or which could improve soil fertility.
9. Provisions must be made for an effective drainage system (preferably with open ditches) in the waterlogged areas; the drains could be designed to keep the water-table below a 1.5-metre depth in areas growing cotton or fruit trees, and below 1 metre in other areas; improvement, realignment (where necessary) and proper maintenance of existing systems.
10. Afforestation of catchment areas, as well as of banks of major streams; in the latter case, especially those parts which are flooded deeply and frequently during a year.
11. Encouraging the use of mechanical implements and power for the improvement/levelling of terraces, deeper tillage and timely opening of the soil surface for maximum absorption of rainwater in the barani areas.
12. Popularising the use of balanced fertilizers by demonstrating their benefits as against the use of urea only, which is abundantly available in the market.

REFERENCES

Ashraf, Mirza M. 1993. Role of vegetation in arresting debris flow and erosion control progressive farming.Vol. 13. No. 1 pp. 17-20.

FAO (Food and Agriculture Organization), 1983. “Report of the Assistance to Rangeland and

Umar F.; M. Ahamd and W. Jasra , 2009. Natural Resources Conservation for Poverty Alleviation by Making the Farmers Partner with Empowerment, Pakistan Development Review, 23rd AGM Papers, PIDE, Islamabad.

Government of Pakistan, 2006. “Pakistan Economic Survey 2005-06”, Economic Advisor’s Wing, Finance Division, Government of Pakistan, Islamabad.

Livestock Development Survey in Balochistan”, FAO, Rome Italy.

Mian, A. and M.Y.J. Mirza, 1993. “Pakistan’s Soil Resources”, Pakistan’s National Conservation Strategy Paper No. 4, Jointly Published by IUCN Pakistan and Environment & Urban Affairs Division, Government of Pakistan.

Noor, M, 1994. Arid land development and combating desertification in Pakistan – National Action Programme. Executive summary, Rangelands Research Institute, NARC, Islamabad.

Qureshi, A.S., Shah, T., Akhtar, M., 2003. “The Groundwater Economy of Pakistan”. IWMI Working Paper 64. Pakistan Country Series No. 19. International Water ManagementInstitute, Lahore, Pakistan. http://www.iwmi.cgiar.org/pubs/working/WOR64.pdf.

World Bank, 2007. “World Development Report 2008: Agriculture for Development”, World Bank, Washington D.C.

Zaffaruddin, C., 1977. “Development of Rangelands in Desert/Arid Areas of Pakistan”, Proceedings of the International Conference on “Alternative Strategies for Desert Development”, Organized by UNITAR and Published by Pergamon Press, New York, USA.

Zia, M. S; T. Mahmood; M. B. Baig and M. Aslam 2004. Land and Environmental Degradation and its Amelioration for Sustainable Agriculture in Pakistan, Quarterly SCIENCE VISION Vol.9 No.1-2 (Jul - Dec, 2003) & 3-4.

Zia, M.S., and A. Rashid. 1995. Soil Management for sustainable agriculture Progressive farming Vol.5, No. 5, pp. 50-60.

Zia, M.S., M. A Khan and M.B Baig. 1986. Management of salt – affected soils of Pakistan Progressive farming Vol. 6., pp 24-29.

About ICARDA and the CGIAR

Established in 1977, the International Center for Agricultural Research in the Dry Areas (ICARDA) is one of 15 centers supported by the CGIAR. ICARDA's mission is to contribute to the improvement of livelihoods of the resource-poor in dry areas by enhancing food security and alleviating poverty through research and partnerships to achieve sustainable increases in agricultural productivity and income, while ensuring the efficient and more equitable use and conservation of natural resources.

ICARDA has a global mandate for the improvement of barley, lentil and faba bean, and serves the non-tropical dry areas for the improvement of on-farm water use efficiency, rangeland and small-ruminant production. In the Central and West Asia and North Africa (CWANA) region, ICARDA contributes to the improvement of bread and durum wheats, kabuli chickpea, pasture and forage legumes, and associated farming systems. It also works on improved land management, diversification of production systems, and value-added crop and livestock products. Social, economic and policy research is an integral component of ICARDA's research to better target poverty and to enhance the uptake and maximize impact of research outputs.

The Consultative Group on International Agricultural Research (CGIAR) is a strategic alliance of countries, international and regional organizations, and private foundations supporting 15 international agricultural Centers that work with national agricultural research systems and civil society organizations including the private sector. The alliance mobilizes agricultural science to reduce poverty, foster human well being, promote agricultural growth and protect the environment. The CGIAR generates global public goods that are available to all.

The World Bank, the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP), and the International Fund for Agricultural Development (IFAD) are cosponsors of the CGIAR. The World Bank provides the CGIAR with a System Office in Washington, DC. A Science Council, with its Secretariat at FAO in Rome, assists the System in the development of its research program.