LAND AND ENVIRONMENTAL DEGRADATION AND ITS AMELIORATION FOR SUSTAINABLE AGRICULTURE IN PAKISTAN

*M. Sharif Zia** Tariq Mahmood* Mirza B. Baig** and M. Aslam***

ABSTRACT

The major challenges facing the world today are to meet the demands of an increasing population and to reverse environmental degradation. Unfortunately, environmental degradation is increasing at a pace that is impairing the productive capacity of our productive lands. Among the many, factors like: soil erosion, salinization, water logging, and desertification are resulting in low crop-yields and deterioration of environment. This paper identifies the factors limiting crop-yields in Pakistan. Also, an attempt has been made to devise suitable technologies to realize sustainable crop-yields, while ameliorating the environmental degradation.

1. INTRODUCTION

Total geographical area of Pakistan is 79.6 mha, only 1/4th of which supports a population of over 140 million. An increase of 2.6% in population per annum forces over-exploitation of natural resources, including soil. Resultantly, the sustainability and environmental protection issues arise in the country. On the other hand, good agricultural-land, meant for crop-production, is shrinking as a result of fragmentation of landholding. It is also accelerated by the rapid use of productive agricultural land for residential and industrial purposes. Thus, the future requirements of food and fiber are to be met by intensifying cultivation on a more-or-less fixed land-resource base. For quite a number of years, it is just possible that potential production may not be achieved, as big yield-gaps exist between the potential that crops yield and the yields actually realized by farmers. Unfortunately, for the past many years, crop-yields of wheat, rice and maize are stagnant, due to deteriorating soil-resources (Zia and Rashid, 1995). Therefore, from the situation, it seems imperative to identify the factors degrading our soil-resources and devise practicable and feasible technologies, in order to realize sustained crop-yields, enhance soil-productivity and ameliorate the degraded environment.

2. CAUSE AND EFFECT OF LAND DEGRADATION

Several constraints to soil and land-resources are adversely affecting agricultural productivity in the country. Anthropogenic, as well as natural processes coupled with population-pressure are responsible for the problems like wind and water-erosion, water-logging, salinity/sodicity, loss of organic matter and decreasing biodiversity. Only constraints like soil-erosion, water-logging and soil-salinity, which are damaging our environment are discussed in this paper.

2.1 The Water-Logging Problem

Pakistan's agriculture depends on the gigantic network of canal-system, as irrigation-system of the Indus Basin covers about 16.6 mha. Water is a critical input to crop-production; but canals are a mixed blessing. On the one hand, irrigation projects require huge budgeting allocations and on the other hand, just after a few decades, the irrigated areas require heavy expenditure for lowering the water-table (resulting from seepage from the interwoven network of canal-system and mismanaged irrigation). According to the Soil-survey of Pakistan, the total waterlogged summer-rain area in the country is 4.11 mha and the waterlogged area is doubled during the post-monsoon season. Depth of water during post-monsoon is about one-third that in pre-monsoon. High water-table has serious adverse affect on agriculture, due to restricted aeration in the root zone, soil salinization, reduced bearing-capacity of soil, weakened foothold of the crops and increased attack of crop-diseases (Zia and Rashid, 1995).

Sustainable Technologies To Control Water-Logging: The following technologies, if properly adopted, can help lower the water-table and manage the problems of water-logging to some extent:

- Installation of tube-wells for irrigation and vertical drainage
- Construction of surface-drains and tile-drains
- Planning and designing of future canals on proper lines.

* Pakistan Council for Science and Technology, Islamabad. ** National Agricultural Research Centre, Park Road, Islamabad.

- Lowering of water-levels of canals.
- Conversion of perennial to non-perennial irrigation
- Lining of water-channels.
- Optimizing water-use, e.g. by avoiding cultivation of high-delta crops on moderately to rapidly permeable soils.
- Planting of eucalyptus in water-logged areas.

2.2 The Problems of Soil Salinity

In Pakistan, approximately 5.7 mha of irrigated land is affected by salinization. Out of this, 44.1% is saline, 55.4% is saline-sodic and 0.5% sodic. Maximum salt-affected areas are in the Punjab (2.6 mha), followed by Sindh (2.3 mha).

Sustainable technologies to control salinity: Reclaiming of saline soils could be an easy task if adequate quality of good water is available. A practice of intermittent deep-plowing and heavy irrigation is adopted, by which salts are leached. Then, rice-berseem rotation helps to leach salts and improve soil-productivity. The last cutting of berseem is incorporated into the soil, to add organic matter. Afterwards, rice-wheat cropping, with sesbania as green manuring crop, should be adopted. If green manuring is not done, then farmyard manure (FYM) should be applied. In this way, the saline land will become productive for improving yield (Zia and Rashid, 1995).

Saline-Sodic And Sodic Soils

Chemical Amelioration Approach: This involves the use of chemical amendments such as gypsum, sulfur and acids. Calcium replaces excess Na from the clay-particles while sodium-sulfate is formed. Sodium-sulfate is a soluble salt and, therefore, can be leached with excess irrigation-water. Sulfur from gypsum produces sulfuric acid, which may also help in reclamation of sodic soil. Deep plowing, chiseling and application of gypsum would help in reclaiming salt-affected soils (Zia et al., 1986) through improving physical conditions of soil.

Biological Approach

In this approach, soil is reclaimed by growing salt-grass, ‘Dhancha’ and other green-manures, and applying FYM, straw and crop-residues.

Physical Approach

It involves deep-plowing, sub-soiling, sanding, and profile-inversion for gypsiferous saline-sodic soil. All these practices will also help in reclaiming saline-sodic soils by improving soil’s physical conditions.

Hydrological Approach

Leaching and drainage are two basic requirements for successful reclamation of saline-sodic soils. When soils are permeable, artificial drainage is not required, but such a condition seldom occurs in saline-sodic soils. Various types of drainage-systems (vertical drainage by installing tube-wells; horizontal drainage; tile drainage; surface drainage) are used for soil-reclamation.

Saline-Agriculture Approach

Saline agricultures refer to economic utilization of salt-affected land for agricultural purposes. In most instances, this means cultivation of salt-tolerant species of agricultural significance and adaptation of special agronomic practices to improve their productivity. In Pakistan, the generally recommended salt-tolerant plant-species include: “Kallar” grass, Artiplex spp, Acacia spp. and Eucalyptus spp. (Zia et al., 1986, Zia and Rashid, 1995).

2.3 The Problems of Soil-Erosion

Area and Types of Soils affected by Erosion:

Soil types vary in their susceptibility to erosion. Soil-erosion occurs mainly in Alfisols, Entiosols, Inceptisols and Mollisols. Water-erosion mostly occurs either in active flood-plains or on sloping hills (affected severely by water-erosion). Wind-erosion occurs in low rainfall areas, like Thar, Thal sand desert of Cholistan and in vast areas of Balochistan.

Sustainable technologies for controlling soil-erosion

(a) The Problem of 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 hazards of soil-erosion. Land-use

practices, vegetation cover, type and structure of soil are other major factors relating to soil- erosion. For example, loose soils of Pothowar Plateau are prone to water-erosion and have potential for gully- formation, taking away highly productive topsoil. In the northern mountainous areas, with steep slopes, the water-erosion is low in the areas with permanently closed canopy-forests, while 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 the efficiency of water and land use. About 40 million tonnes of soils are brought into the Indus-basin each year. It shortens the life-span of major reservoirs and reduces their efficiency. The upstream, riverside infrastructure is destroyed and top-soil is washed away, decreasing productivity of the area. In downstream, the sediment reduces the efficiency of hydropower-generation and irrigation-system (Ashraf, 1993; Noor, 1994; Zia and Rashid, 1995).

(b) Sustainable Technologies For Controlling Water Erosion: Water-erosion is mainly caused by the hammering action of raindrops and flowing water. Water-erosion can be reduced / controlled by:

- Provision of surface-cover that intercepts the rain before hitting the soil.
- Reducing the amount of runoff by promoting infiltration.
- Controlling flow of water by making it flow to where it is desired to be taken, at a controlled velocity.
- A good cover of grass will provide nearly all these actions. The following practices are suggested for effective control of water-erosion:
- Maintenance of borders ("Watbandi" land- leveling and terracing) in the field.
- Cover cropping
- Minimize clean cultivation
- Stripe cropping
- Stubble mulching
- Minimum tillage
- Construction of drop-structure
- Flood-retarding structure
- Minimize grazing and cutting (Zia and Rashid, 1995)

(c) Sustainable Technologies for Controlling Gully Erosion: The gullied land cannot be economically reclaimed. However, control of runoff and erosion is important on this type of land, to stop further deterioration. Vegetation covers of such lands are improved through controlled grazing. Small and medium-sized gullies, with suitable outlet, could be controlled effectively with diversion of run-off at the gully heads. For large gullies, construction of drop-structure is important for slowing down runoff to non-erosion velocity. Impounding of runoff water at gully-heads can also stop the advancement of gully, besides providing drinking water (Zia and Rashid, 1995).

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 water-ways 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).

(d) Sustainable Technologies for Steep Sloping Land: Steep sloping land occurs mainly in northern and western mountains. Zia and Rashid (1995) stress that in northern mountains, priority needs be given to:

- Building stone bench-terraces in the cultivated area.
- Further expansion of cultivated areas should be discouraged on mountain-slopes greater than 15%.
- Soils should be used for forage-production instead of growing maize, by introducing a mixture of legume and grasses.
- Special measures should be taken to improve existing bench-terraces and provide water-disposal system, including grassy waterways and drop-

structures.

- Modern range-management measures must be adopted to improve rangelands.

2.4 The Problems of Wind-Erosion

Land degradation by wind-erosion is queit common in the sandy deserts of Thal, Cholistan, Tharparkar, and sandy areas along Makran Coast. The proximate physical cause of erosion is the general aridity. Erosion is significant in the areas around habitations and watering-points trampled by livestock. Here, the major degrading factor is the over exploitation of rangelands for fuel-wood 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 0.5m to 4m high moving sand-dunes posing danger for cultivated land infrastructure. Some 3.5 million hectares are affected by wind-erosion. The amount of soil removed by wind is about 28% of total loss of soil. High-velocity windstorms cause movement of sand-dunes, depositing thick layers of sand on roads, railway tracks and croplands, and threatening village inhabitants. Organic matter and other soil-nutrients are lost, along with fine soil-particles during movements (Muhammad, 1994).

(a) *Sustainable Technologies for Controlling Wind Erosion:* Wind-erosion prevention can be achieved by adopting less aggressive methods of cultivation that maximize residue-conservation and reduce soil-pulverization. Zia and Rashid (1995) gave the following cultivation-options to prevent wind-erosion:

(b) Cultivation Techniques: These includes

- Tined implements, rather than disc could be used, as the latter buries more surface-residues.
- Blade and chisel plow, with seep points, should be used.
- Frequency of cultivations should be reduced, to avoid greater soil disturbance.
- Implements, such as chisel plow, which go deep into the soil and produce good clods, should be used.
- Soil-clods greater than 2cm should comprise 50% of the soil-surfaces.

Vegetation cover helps in controlling erosion in a number of ways, namely:

- It traps eroded soil-particles and reduces their erosive power.
- It can adsorb the force of wind and thus reduce wind-speed at ground level
- It can act as a cover against the wind-forces, preventing erosion; i.e. preventing wind from removing soil.

At least half of the ground should be covered with vegetation, otherwise, erosion can occur. The following measures need tobe adopted for controlling erosion with the use of vegetation:

- Effective control of grazing and a check on the uprooting, cutting and burning of natural vegetation.
- Growing hedges around cultivated fields located near active sandy ridges and exposed to winds.
- Strip-cropping for the control of wind-erosion. Wind-breaks around the erosion-vulnerable areas to slow down the wind.

3. CONCLUSIONS AND RECOMMENDATIONS

In order to feed the rapidly multiplying population and to keep the land resources in good condition, for the future generation, and to overcome the environmental issues related to natural resources, it is of paramount importance to halt and overcome the process of land-degradation, by:

- Adopting strategies to overcome the problem of water-logging in Pakistan.
- Managing White alkali (Saline soils) through intermittent deep-ploughing and heavy irrigations.
- Managing black alkali (Saline sodic / sodic – black soils) through the use of chemical amendments (like gypsum, calcium chloride, sulphuric acid, hydrochloric acid, sulphur and ferrous sulphate, by-product of sugar industry (press mud), biological approaches, such as use of FYM, green manures; composts, and physical methods, such as deep plowing, chiseling and sanding.
- Managing unfit underground water for crop-production.
- Managing water and wind-erosion to reduce and halt the loss of soil fertility.
- Integrate soil-fertility and fertilizer-management for improving crop-yields, rejuvenating soil health and

sustaining soil-productivity.

Since the chemical reclamation process is a time-consuming and costly business, and hence out of reach of ordinary farmers, therefore, bio-saline approach is another option for growing salt-tolerant crops, shrubs, fruit, and forest trees.

Finally, we should overcome the problem of rapidly growing population, to reduce the pressure of population on the natural resources.

REFERENCES

1. Ashraf, Mirza M. 1993. Role of vegetation in arresting debris flow and erosion control progressive farming. Vol. 13. No. 1 pp. 17-20.
2. Noor, M, 1994. Arid land development and combating desertification in Pakistan – National Action Programme. Executive summary, Rangelands Research Institute, NARC, Islamabad.
3. 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.
4. Zia, M.S., and A. Rashid. 1995. Soil Management for sustainable agriculture Progressive farming Vol.5, No. 5, pp. 50-60.