THE ROLE OF FORESTRY IN WATERSHED MANAGEMENT AND SOIL CONSERVATION

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Introduction:

In Pakistan, the area of watershed and range lands constitutes about 65 to 70 percent of total land area. These areas are in depleted condition and far below their productive potential. Because of continued misuse through deforestation, unchecked grazing and irresponsible extension of cultivation, the watershed lands have been severely damaged with the result that agricultural production has considerably decreased.

Under Indus Water Treaty, 1960, Pakistan lost 33 million acre-feet water of three Eastern rivers-Sutlej, Beas and Ravi after 1970. Water and Power Development Authority proposed construction of 2 big Dams-Mangla and Tarbela to supplement the withdrawal of water by India. M/S Hunting Technical Services Ltd indicated in their report that the misuse of forests, and cultivation of steep slopes has resulted in accelerated erosion process. It has been estimated that Mangla and Tarbela reserviors will be completely silted up in 100 and 90 years respectively.

Pakistan is dependent on water storages for production of hydro-electricity, irrigation water, and in some situations for domestic water supply. Hence loss of storage capacity due to sedimentation causes serious economic loss. In addition there is the production loss throughout watersheds due to accelerated run-off and consequent soil erosion. Soil protection is required to ensure sustained production of forest and agricultural products. Improved watershed management is essential for increased sustainable production, reduced soil erosion and improved perenniality of stream flow.

As a result of destruction of vegetation and gradual denudation of hilly catchments, sedimentation release and run-off have increased manifold resulting in recurrent annual floods causing colossal loss of life and property every year. In 1955 the flood inundated 2420 villages levelling 3112 of them. Built of mud bricks, village house do not stand up long to flooding, 400 people and 70,000 cattle lost their lives. The standing crop was ruined over an area 101,911 hactares. The total damage caused by the flood amounted to Rs. 83 million (Johnson, 1979).

Apart from this, other past flood have wrecked enormous destruction to life and property. Between 1973 and 1978 five serious floods have victimized 12.7 million persons (1,516 person killed) and cost perhaps £15 million (U.S. Aid 1979). Floods in 1973 inundated approximately two million ha of crops and ten thousand villages.

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PAKISTAN: ECONOMIC LOSS BY FLOOD DAMAGE FACTORS FOR PUNJAB, SIND NWFP AND BALUCHISTAN

Location	Flood Damage Factors: Rural Areas, Rupees/Acre inundated	Flood Damage Factors: Urban Areas, Thousand Rupees/Acre inundated
Punjab		
Sutlej River	650	121
Ravi River	650	121
Chenab River	575	121
Jhelum River	550	121
Upper Indus River	425	121
Sind		
Lower Indus/Right Bank	550	105
Lower Indus/Left Bank	650	105
NWFP		
Swat River	825	60
Kabul River	900	60
Upper Indus River	725	60
Baluchistan		
All Rivers	375	50

Source: GOP (1978) Federal Flood Commission, National Food Protection Plan.

Present Situation of Land Degradation:

The watersheds of the Indus Basin rivers have unfortunately suffered from excessive wide spread felling of woody vegetation and heavy overgrazing in the past many centuries. The land is being cultivated even upto 8,000 feet altitude above and on slopes, not at all suited to it. Several million tons of soil is removed annualy from our watersheds by water erosion. This sediment is subsequently deposited in streams, channels, lakes, reserviors and harbours, requiring costly remedial measures to keep up their useful lives. Sediment studies in Pakistani rivers have been carried out from 1916. In early seventies soil at the rate of 4–7 thousand tons per square mile was carried annualy in the river Chenab and Jhelum (GOP 1973). According to recent estimates the sediment load in the Indus is greater and in fact one of the highest in the world.

Terbela Dam had a capacity after construction in 1974 of 11.62 million ac.ft. In 1984 this had been reduced to 10.03 million ac.ft. due to sedimentation. At the current rate of sedimentation the projected life of the storage is 80–90 years. Much of the sediment is in the form of bedload which would not be affected by land treatment. An evaluation of the impact of watershed management activities undertaken in the Mangla catchment has indicated that the economic life of Mangla Reservior, provided it were solely dependent upon the rate of siltation, has been lengthened by about 60 years through the reduction in soil erosion and siltation rates achieved during the past 25 years in the catchment area (IBRD, 1985). The storage of Rawal Dam was constructed in 1960 and has a maximum capacity of 47,500 ac.ft. and a catchment area of 106.25 sq. miles. Sedimentation of the storage indicates a loss of 10,000 ac.ft. capacity of about 30% over 24 years. The life of the storage could be significantly extended if an adequate watershed improvement programme is implemented in the catchment.

In the Northern area the Hunza river is the major sediment source for the Terbela storage. WAPDA has assessed the contribution of sediment from this watershed as 5.17 Ml/km^2. In this difficult environment of low rainfall, (under 250 mm) winter cold, steep slopes and erodible soils, the critical sediment source is from under cutting of stream banks with consequent slumping and the undercutting of the toe of landslides rendering them unstable.

Most of the sediment form these sources arises during high flows which occur after snowmelt in the June-September period. Periodically the river is blocked upstream of Hunza by debris from glaciers which forms a temporary lake. Subsequent breaching of the debris bank releases large amounts of water and debris with consequent accelerated erosion.

Importance of Vegetation in Watershed Improvement and Soil Conservation:

Adequate vegetative cover on watershed lands is of primary importance to protect the soil from the powerful forces of wind and water erosion. Tree vegetation, in particular, acts as natural windbreaks, absorbs the impact of heavy rainfall, reduces run-off and moderates the flow of streams. Indiscriminate removal of vegetation from these sensitive areas has accentuated washing away of the fertile top soil in the event of heavy rains.

The removal of forest vegetation and subsequent use of the land for regeneration of new forests can produce significant changes in the hydrologic function of the catchment and in the quality of water. The removal of forests produces changes in streamflow yield. When vegetation gets cleared from a particular catchment on account of excessive biotic pressure the hydrologic response often increases. Conditions become more congenial for excessive run off resulting in higher peak flows for a given amount of precipitation input. Degree of vegetation removal is, therefore, a major factor which influences streamflow.

The beneficial role of tree covered lands in the catchment areas is well known. They maintain the optimum conditions for the reception of precipitation by soil, and act as the first line of defence against surface flow and all its consequences. In the regions where precipitation is in the form of snow, the controlling influence of forest on snow interception, snow drifting and shielding of snow pack, is well known. In view of these facts the protective function of forests in hilly areas has gained considerable recognition and it has, therefore, become obligatory to evolve and enforce methods for the protection, conservation and management of forest cover in the degraded watershed lands. Maintenance of adequate forest cover is of vital importance in the hilly areas for the conservation of soil and the life of the springs on which the fertility of the land and the prosperity of the people are so essentially dependent.

In the years following 1837, when the Tàbleland in Western Victoria was first settled, the new landholders drastically thinned large tracts of Eucalyptus woodlands. Unfortunately they allowed their stock to cvergraze the native vegetation. Rabbits and forest increased the pressure, and the pastures deteriorated. Because much less water was transpired than before, the delicately poised "hydrologic balance" became upșet. Surface runoff and deep seepage increased and today the solodic and lateritic podzolic soils of this dissected plateau have become scarred with salted drainage lines, eroded gullies, and landslips (Cope 1958). To help restore the hydrologic balance, farmers have been advised to plant the naturally occuring Eucalyptus species which has a deep and extensive root system. Moreover, its roots are able to reach not only water deep in the subsoil, but also reserves of nutrients, and to circulate them back to the surface.

Afforestation as a Mean to Rehabilitate Degraded Watersheds:

Planting of degraded watersheds with suitable tree species is the most effective measure to reduce runoff, sediment release and increase infiltration. Afforestation of marginal and sub-marginal denuded hill areas with species of economic importance can mitigate the recurring flash floods. In the beginning, people were rather prejudiced against planting as they had the suspicion that any tree planting agency afterwards will acquire the land they have planted. Well-organized and comprehensively planned afforestation programme for these areas are of vital importance to fight against the menace of soil erosion and sedimentation in our watersheds.

Planting of *Melia azedarach*, Pistacia spp., Ailanthus spp. and Robinia has been found quite suitable in the northern watersheds of Mangla catchments. Except Pistacia, the survival of other species was quite encouraging when planted on the boundaries of the cultivated fields and around houses. Afforestation of Chir pine, Robinia and Ailanthus have been successfully undertaken in the catchments of Tarbela in the Hazara Division. Ailanthus has been found to be a good soil binder and a quick growing species. Planting of Robinia for getting quick fuel-wood returns is also much favoured. Kikar, Phulai and Robinia have been very sucessful in foothills. Willows, Poplars and Arundodonex (Nara) have been found quite successful for planting behind check dams and gully plugs for arresting silt with their deep roots.

The protection of soil through afforestation by different species gets priority by all watershed management programmes. If any area is effectively protected from the biotic incidence of man and livestock, in couple of years the native tree flora of the area starts appearing and establishing successfully. However, in such areas where planting is essential but it cannot be effectively protected from grazing, artificial methods of afforestation will be adopted. Moreover, selection of a suitable species in accordance with soil and climate of the area is extremely important. Some suitable tree species depending upon different types of soil and climatic conditions, are listed as under:

- **Areas up to 3,000 feet height:** ***Acacia nilotica, Acacia modesta, Dalbergia sissoo, Azadirachta indica (Bakain),*** **Impomea, Arundodonex (Nara),** ***Dodonea viscosa*** **(Sanatha) and Vitex.**

- **Areas from 3,000 to 6,000 feet height: Robinia, Saphindus, Chir, Ailanthus, Bakain, Poplar, Willow, Apple, Prunus spp., Almonds.**

- **Areas above 6,000 feet height: Robinia, Pines, Walnut.**

The above-mentioned species can be raised through different techniques of planting. Direct sowing from seed is encouraged for most of the species as it saves lot of overhead expenses. Planting of root and shoot cuttings is also an established technique in respect of many species of economic importance. Planting of entire saplings alongwith earthball with or without a polythene tube is a very popular practice for a large number of tree species. This technique is, however, expensive but relatively more certain and successful.

Results of Watersheds Provided with Different Types of Tree Cover:

Pakistan Forest Institute, Peshawar during the year 1969 initiated a comprehensive watershed study at Missa near Gujar Khan in the Kanshi river catchment of Mangla Dam. The study was designed to evaluate the effectiveness of soil conservation works and reaforestation on run-off and soil losses. Results (1973–83) showed that the treatment reduced run-off by 40 percent and sediment yield by 37 percent. In the Rawal Watershed Management Project of Satrameel being sponsored by Pakistan Agricultural Research Council, the analysis of the data showed a reduction of sedimentation loss from 0.0317 tons per 100^3 m of sampled water from controlled watershed to 0.000997 tons from the treated watershed during the year 1984 to 1986.

Eucalyptus camaldulensis is being extensively grown in diversified habitat in Pakistan. Research in Australia has shown that the species recycle nutrients from deep sub soil with consequent benefit to pasture growth. This knowledge can be useful in extension to encourage landowners to plant this species in the watershed areas. Similarly the tree Casurina cunninghamiana has been found to be the most effective tree to control gully erosion in the State of Victoria, Australia, while in the State of New South Wales it is protected by law because it protects streambanks from erosion. The tree is frost resistant and has the attribute of suckering form fiberous roots if damaged. The tree can also be very useful in the humid sub-tropical and in the temperate ecological zones.

The Government of China has taken a series of comprehensive measures aimed at soil and water conservation by mobilising their masses to plant trees for covering denuded hills and reforestation in the state forests, which were subjected to devastation during the wars. The programme has produced remarkable results. Various species of Eucalyptus tried were *E.excelsa, E. citriodora, E. tereticornis E. globulus,* all worked on a rotation of 12 years. Means annual rainfall in this tract was 1400 mm and it was claimed that after afforestation not only this has increased to 1500 mm but soil evaporation losses have also been considerably reduced.

Planting of *Leucaena leucocephala* over an area of 700 hectare within Marikina Watershed Reservation in Phillipines showed very positive results and the once denuded watershed was very successfully reforested. An inventory conducted in the area provided 85 percent survival of the species planted at 1 m x 4 m spacing. Ninety percent of these surviving were of merchantable quality with an average dbh and height of 10 cm and 4.5 m respectively. The project besides proving quite effective in drastically reducing runoff and sedimentation losses from the area also generated handsome income after four years.

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