

WATERSHED MANAGEMENT IN PAKISTAN: ACHIEVEMENTS AND ISSUES**

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ABSTRACT

The major part of the northern mountains and a part of the Pothwar plateau constitute the major watersheds draining to the tributaries of the Indus Rivers System. Infact, the watersheds of Tarbela, Mangla and many small dams fall in to this area. These watersheds have unfortunately suffered from excessive and wide spread felling of woody vegetation and have overgrazing in the past century. The sediment is subsequently deposited in streams, channels, lakes, reservoirs and harbors, requiring costly remedial measures to keep up their useful lives. Sediment studies in Pakistan's rivers have been carried out since 1916. The geologic erosion is predominated in the watersheds of the Indus, Kabul and Swat rivers, whereas accelerated erosion is caused by defective landuse in the watersheds of other tributaries of Indus and Jhelum. The forest area is only 5% of the country's geographical area and is defined legally and not biologically because of the definitional difficulty due to colonial legacy and thus area is insensitive to the number of trees. The Indus river system is being operated in accordance with Indus Water Treaty and Indus Water Apportionment Accord.

The systematic watershed management programme in the Tarbela and Mangla dams were started in early 60s using traditional approaches. The active participation of communities started in early and mid 80s under the integrated mountain development programs. The early traditional programs had a reasonable effect in Mangla dam area compared to the Tarbela dam. Coupled with recent participatory approaches, the watershed management in Mangla dam had reasonable impact on reduction of sediment load to the streams entering the Mangla Lake and now the predicted life will be around 182 years instead of 110 years of the designed life. Whereas, there is no significant improvement in reducing the sediment load to streams entering the Tarbela dam primarily due to excessive geologic erosion in the watershed area.

The integrated development and rural support programs introduced during 90s resulted into active participation of communities in managing natural resources of these watersheds and maintaining equity in access to increase community livelihoods. These programs were also very successful in addressing the issues of the neglected segments of communities especially landless and women. The paper recommends that the success of watershed management programs depend on the optimal blend of social, economic, ecological, political and site-specific realities through active participation of communities. The project approach is too much focussed on targets and there is a need to have a program approach instead of getting stuck in the dialogue of bottom-up or top-down approach. Infact, there is a need to have a balance approach. The other issues related to technological, social and management aspects were described and recommendations were made. The most critical recommendation is that watershed problems must be seen from the management and social end instead of merely the technological end.

1. INTRODUCTION

Country's geographical area is around 88.2 million hectares including the Northern Areas. The country has a great diversity of bio-climates and correspondingly a great diversity of vegetation types and fauna. The major habitats in the country range: a) from flood plains, arid plains, and sand and piedmont deserts to a variety of forests; b) grassy tundra and cold deserts; and c) lakes, rivers, swamps, and coastal marine habitats.

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Physiographically the country can be divided into three major regions: a) high northern mountains; b) Indus plain; and c) lower and more arid western highlands. In addition to these, a relatively small area in the north-west of the Indus plain comprises the Pothwar plateau and salt range, which have elevations ranging between 450 to 600 m. The plateau has badlands topography due to dissection by water and wind erosion (NCS 1991).

Major part of the northern mountains and a part of the Pothwar plateau constitute the major watersheds draining water to the tributaries of the Indus Rivers system. In fact, the watersheds of Tarbela, Mangla and many small dams fall in to this area.

Notwithstanding the diversity of topography and climate, Pakistan is basically a dry country of the warm Temperate Zone. Except for a small strip of the sub-tropical terrain in the Punjab and the wet zone on the southern slopes of the Himalayan and Karakoram mountain ranges, most of the country is arid or semi-arid steppe land. In all, more than three-fourths of the country has less than 250-mm rainfall, and thus less than 25% area is important from the viewpoint of watersheds (NCS 1991).

Watersheds of the Indus Rivers system have unfortunately suffered from excessive and wide spread felling of woody vegetation and have over-grazing in the past many centuries. The land is being cultivated even more than 2500-m altitude and on steep slopes, not at all suited for farming. Several million tons of soil is removed annually from the watersheds by water erosion. This sediment is subsequently deposited in streams, channels, lakes, reservoirs and harbors, requiring costly remedial measures to keep up their useful lives. Sediment studies in Pakistan's rivers have been carried out since 1916. In early 70s, soil at the rate of 3-5 thousand tons per km² was carried annually in the rivers of Chenab and Jhelum (Saeed 1974).

Geologic erosion is predominated in the watersheds of the Indus, Kabul and Swat rivers, whereas accelerated erosion is caused by defective land use in the watersheds of the other tributaries of the Indus, and of Jhelum (Ahmad and Pervaz 1963).

Forest area is 5.3% of the country's geographical area. This area is defined legally and not biologically because of the definitional difficulty due to the colonial legacy. As a result, the estimate of forest area is insensitive to the number of trees, but responsive to changes in areas commanded by the control of the Forest Department. Therefore, the increase in forest area of around 3% at the time of independence to 5.3% has no correlation with the quantum of forestry in the country. On the contrary, widespread anecdotal evidence – in the form of political statements, record of public hearings and journalists' accounts – suggest that there has been a significant reduction in natural forests over the last 30-40 years, a process which may feel is still continuing (GOP et al 1992; NCS 1991; Shah 1989; Shah 1991; Ali 1990; Minissale 1991). The loss of vegetation especially in watershed areas has direct impact on erosion of top fertile soil and increased sediment load to the stream flow. The sediment load in the stream flow ultimately affects the live storage of the large hydropower reservoirs. Thus, reducing the capacity for storage of water and power generation.

Main source of surface water is the Indus basin irrigation system. It consists of river Indus, its eastern tributaries of the Jhelum, Chenab, Ravi and Sutlej, and the northern and western tributaries of the Kabul, Swat, Haro and Soan. The use of Indus waters is governed by two major political agreements, the Indus Water Treaty 1960, between India and Pakistan, and more recently the Indus Waters Apportionment Accord 1991, between the four provinces of Pakistan.

Indus Water Treaty allowed exclusive rights to India to the waters of the Ravi, Sutlej and Bias Rivers, while the waters of the western rivers, Indus Jhelum, and Chenab were assigned to Pakistan. Since the treaty effectively cut off the water that flowed from India to Ravi and Sutlej rivers, the Indus basin works, consisting of two dams and 10 link canals, were constructed to alleviate the problem.

Indus Water Apportionment Accord assumes a total allocable supply of 141 billion m³, which is 12 billion m³ higher than existing canal withdrawals. This increase is based on the assumption that the outflow in

to delta can be decreased from its current average level of 25-30 billion m³ to about 12 billion m³. Detailed studies are to be commissioned on the needs of delta in general and the coastal mangroves in particular.

System fed by glacier and snowmelt and rainfall primarily outside the Indus basin, records average annual flows of approximately 172 billion m³ (WSIPS 1990). However, flows exhibit considerable variations, both annually and seasonally: annual flows range between 231 billion m³ in 1959-60 and 124 billion m³ in 1974-75, and the average Kharif flow of 142 billion m³ is over five times the average Rabi flow of 27 billion m³ (Mohtadullah et al. 1991).

Indus system includes three main artificial reservoirs at Mangla, Tarbela and Chashma with original total live storage capacity of 19 billion m³, which has reduced to 18 billion m³ by 1988 (GOP et al. 1992). The recent estimates made by WAPDA indicate that today about 22% and 17% live storage capacity of Tarbela and Mangla reservoirs have been lost. This means that today the total live storage capacity in the three large reservoirs is around 15 billion m³. This also shows that management was much better in the Mangla watershed compared to the Tarbela watershed (PWP 1999).

Watersheds and range lands (including the degraded and arid rangelands) constitute about 65 to 70 percent of the country's area (Ashraf 1987). These areas are in depleted condition and far below their productive potential. This is because of continued misuse through deforestation, unchecked grazing and lack of appropriate management of steep slopes for cultivation. The watersheds have been severely damaged with the result that agricultural productivity has been considerably decreased.

Studies conducted in the past have clearly indicated that indiscriminate exploitation of forests and cultivation of steep slopes have resulted in accelerated runoff and soil erosion process. Due to sediment load in the stream flow the Mangla and Tarbela Dams will be completely silted up within about 110 and 50 years, respectively, since the completion time of these reservoirs as per design parameters, if watersheds environment is not improved considerably (WASID 1967).

Paper includes review of the past achievements related to watershed management in the country. This is a first effort and further strengthening is required to improve the paper. However, the work done is presented in major areas of: a) government programs; b) sustainable mountain development; c) impact assessment of watershed management programs; d) target group analysis for social, economic and ecological impacts; and e) issues and recommendations.

2. ACHIEVEMENTS

2.1. Government Programs in Watershed Management

2.1.1. Soil and Water Conservation in Barani Areas

Government undertook various programs in the country for watershed management. Over a century ago, the Punjab government expressed concern for the growing damage of soil erosion due to unregulated exploitation of the forests. The first substantial Government measures to control erosion were reflected in passing of the Punjab Land Preservation Act, 1900 (Punjab Act II 1900). The Forest Service was given power for restricting and regulating the use of certain tracts of land. Enforcement was seldom exercised until soil conservation work was entrusted to a competent agency. In 1941 a separate "Soil Conservation Circle" in the Punjab Forest Department was organized. The Punjab Land Preservation Act of 1944 extended land preservation to all of the Punjab province which promoted many catchment plans to be prepared for the province with three objectives of: a) afforestation; b) soil and water conservation for agricultural lands; and c) control of hill torrents (Gorrie 1946).

In 1951, a Central Soil Conservation Organization was created to assist and coordinate nation-wide

soil conservation activities. This effort was further strengthened by a partnership between the West Pakistan and the US Government and established a Soil Conservation Pilot Project in 1954. The project area was expanded to include about 20 demonstration sites over approximately 8,000 hectares. Since there was great demand outside project areas from farmers by 1956-66, demonstration units were expanded to cover the whole district. The 50% government subsidy for conservation assistance soon exhausted all funds Government had allocated. Problems mounted and funds were inadequate to support research. Furthermore, there was no provision for economic analysis of the project (DSC 1994).

Soil conservation programs were expanded with the establishment of the Punjab Barani Commission and the Agency for Barani Area Development in 1975. In early 80s, the development in the Barani areas was given impetus through funding of the First Barani Area Development Project covering selected tehsils of the Pothwar Plateau. The program was expanded till 1998 under the Second Barani Area Development Project. This project expanded the scope of soil conservation activities based on the research work done by PARC, where water conservation was accepted as equally important and essential element of the program. Therefore, activities like construction of ponds and mini-dams were included as project interventions and less emphasis was placed on the traditional interventions. Furthermore, dugwells, handpumps, lift and pressurized irrigation systems were introduced for small farmers. The third phase is now being executed from 1999-2000 under the Barani Village Development Project (DSC 1994; IFAD 1992; DAI et al. 1988; PARC 1986).

2.1.2. Mangla Dam Watershed Management Program

The large-scale activity of watershed rehabilitation was started in 1959 when M/S Hunting Technical Services Limited was given the assignment of surveying the catchment area of the Mangla dam. They submitted the integrated plan in 1961. Work on 10 demonstration sites (4 in Azad Kashmir and 6 in Pakistan) covering an area of 768 km² was started. This scheme covers about one tenth of the total catchment area between Mangla Dam and Muzaffarabad.

Mangla dam was completed in 1967 with a live storage capacity of 6.5 billion m³. It costs Rs. 3.172 billion to construct. Each year since it was built, the dam has lost about 0.04 billion m³ in capacity, mainly due to siltation arising from watershed degradation in the upstream area. About 56 and 12% of the watershed area fall under rivers Jhelum and Poonch, respectively, whereas the rivers Jhelum and Poonch contribute about 60 and 23% of sediment load to the dam, respectively. The other streams are rivers Kunhar and Neelum. The population density in the catchment area ranges from 350 to 1000 persons per km² of cultivated area, which is many times higher than the country's average population density (Akram 1968; WAPDA 1986).

A wide range of watershed management practices has been implemented under various projects. A pilot watershed management project began in 1966. In the beginning, the watershed management practices placed most emphasis on earthen dams with drop inlet structures. These were constructed using earthen bunds and prescribed slopes. The drop inlets were used to control flow of water. In case of earthen dams, planting of *Cynodon dactylon* grass followed compaction, but rodent holes, animal grazing and lack of maintenance by the owners rapidly resulted in damage to the earthen dams. Subsequently, stone rubble or masonry structures, small dams, spillways and bed profiles were designed and implemented.

There was a strong emphasis on planting pine trees, although fruit trees and other fast-growing forest trees were also introduced later. Planting on land not fit for cultivation was carried out by the project, while planting on field boundaries was left to the landowners. The other biological treatments introduced in the Mangla watershed management project included: a) groundnut to provide cover in the monsoon season; b) rats eradication; c) Napier millets for stall-feeding of livestock; and d) introduction of Sisal plants (*Agave*) to control soil erosion. Some plantations survived, but many were damaged as protection from free-grazing animals and maintenance of widely scattered patches of plantation could not be ensured (Ishaq 1968). The conservation structures were successful where the siting of structure was correct and feasible. However,

heavy monsoon rains and lack of maintenance damaged the stone structures after three or four years. Cynogas poison was used to eradicate rats, but again success was only partial because of a lack of community participation and lack of an area-based approach (Ahmad and Ahmad 1999).

The first operational project was started in 1966 for a period of 24 years. After several evaluations and revisions, a new scheme was prepared for the period July 1983 to June 1988, which included a 'food for work' component by the World Food Program. The evaluation wing of the Planning Commission reviewed the project in 1982. The principal findings include a reduction of 34% in sedimentation from 63.6 to 42.2 million m³; which means an increase in useful life of the reservoir from 110 to 172 years. The project also lacked manpower management and there does not exist any cooperation with or from local people (WAPDA 1986; Ahmad and Ahmad 1999).

Pakistan Forest Institute, Peshawar initiated a comprehensive watershed management experimental study at Missa Kiswal in the Kanshi river catchment of the Mangla Dam during 1969. The study was designed to evaluate effectiveness of soil conservation works and reforestation on runoff and soil loss. Results of the period from 1973 to 1983 showed that the management interventions reduced the runoff by 40 percent and sediment yield by 37 percent (Hanif 1988). Subhan (1985) further evaluated the effects of intensive management interventions during the period from 1982 to 1984 in the Missa sub-watershed. These management interventions comprise of fencing, planting of suitable plant species, repair and raising the level of existing check dams and spillways, and construction of new structures. These interventions resulted in a decrease in runoff of 46% and reduction in sediment load of 77%. Hanif (1992) further reported a 51% reduction of runoff due to the watershed management interventions over the study period.

Some participatory activities were initiated in the Mangla watershed in mid 80s under the World Food Program, where interventions like afforestation, soil conservation and range management were introduced and fruit plants were provided to local farmers. The objective was to convince the local communities to spare their lands for afforestation activities and in return to get food materials for work so rendered on their own lands. The local people hesitated to accept the program in initial stages with the fear that Government would snatch away their resources. However, after getting enhanced income from fruit trees, grasses and reclaimed agricultural land, the local farmers were convinced that the government is keen to improve the livelihood of poor people (Khan 1989).

Loss of the live storage capacity of Mangla dam is around 17.5%; considering an annual rate of sedimentation of 0.55%. This means that the potential life of the dam would be around 182 years instead of 172 years. Therefore, the watershed management programs have positive effects on the control of sediments (WAPDA 1986; Ahmad 1993; PWP 1999).

The evaluation team recommended that watershed management should: a) avoid piecemeal work and concentrate on contiguous area; b) give priority to propagation of fruit plants that had not been given adequate attention in the past; and c) give attention to the improvement of range lands and cultivated areas. It was also recommended that the project should not be transferred to the Provincial Forestry Departments, and that WAPDA should continue its operation.

The problems encountered in the project implementation were identified: a) absentee landowners; b) grazing pressure; c) lack of cooperation and participation of local communities; and d) poor maintenance.

2.1.3. Tarbela Dam Watershed Management Program

Tarbela dam is the world's largest earth-fill dam designed for hydropower. The gross and live storage capacities are 13.7 and 11.5 billion m³. The project started supplying water in 1975 and power in 1977 through its first four power units. The construction cost was Rs. 14 billion. The present capacity of generation is around 5228 MW. Estimated rate of sedimentation was 0.23-0.24 billion m³ per annum and

thus estimated design life is 55 years. Sediment comprised of 60% sand, 53% silt and 7% clay. The Indus river watershed area is 91% and contributes around 91% sediments to the lake, whereas Siran and Swat rivers watershed area are 2% and 7%, respectively, and contribute around 7.7% and 1.3% sediments, respectively. The Siran River contributes higher rate of sediments. The average rate of sediment to the lake is around 0.153% of the discharge (WAPDA 1986; Ahmad 1993).

Watershed management project began in 1964-65 in the form of pilot project. It was expanded in 1971-72 with the support of the World Food Program in to Kaghan valley and Duar watersheds. This project was implemented by the Forest Department of the NWFP in collaboration with Water and Power Development Authority (WAPDA). Further expansions were made in 1977 to cover four divisions east of Indus, and in 1984-85 to include Kohistan and Bunair districts to the west of Indus. The latter project was ended in June 1993. The current project is now a second phase of the World Food program and also supported by the German Development Bank, Kreditanstalt für Wiederaufbau (KfW). The Tarbela watershed management program has minimal impact on sediment control; as 29% of the live storage capacity has already been lost; considering an annual loss of 0.86% per annum (WAPDA 1986; Ahmad 1993; PWP 1999).

2.1.4. Rawal Dam Watershed Management

Rawal dam was built in 1962 on river Korang, a tributary of river Soan to provide water mainly for domestic purpose to the twin cities of Rawalpindi and Islamabad. The total watershed area is 170 km² with annual rainfall ranging between 750 to 1500 mm. Standard watershed management operations are carried out by the Capital Development Authority (CDA) and the Punjab Forest Department. The WRRI-NARC is engaged in experimental watershed management operations at Satrameel, where experimental catchments of 16 hectares size are gauged for runoff and sediment load measurements.

The sediment load in the monsoon season is many folds higher than the dry season. The sediment load varies from 0.2 to 1.1% (WRRI-NARC).

2.1.5. Shahpur Dam Watershed Management

Shahpur dam is a concrete gravity dam with centrally located spillway in body of the dam. The catchment area is about 20,402 ha and the total storage capacity is around 17.7 million m³, out of this live storage capacity is 5.04 million m³. The mean annual inflow to the dam is around 20.6 million m³, which is 1.16, and 4.09 times the total and live storage capacity of the dam, respectively. These ratios indicate that the Shahpur dam is hydrologically more endowed compared to other small dams. The Shahpur dam provides about 289 mm/ha of gross water depth considering command area of 1744 ha. This is almost 40% of the actual crop water requirements. Therefore, the actual command area is less than the designed. In reality, it is only or less than 100 ha (WRRI 1997).

Watershed management in the catchment area is not appropriate as the surface cover in the winter season is only 28% based on the image processing of the LANDSAT TM satellite data. However, the dam has contributed significantly in recharging the groundwater. The monitoring study conducted by the WRRI-NARC revealed that water-table in the wells closer to the dams periphery is less than 3 m compared to around 30 m prior to the construction of the dam. The WRRI-NARC is monitoring 50 geo-referenced farmers' wells for well characteristics and groundwater levels. In addition, the dam is providing freshwater fish (WRRI 1995).

2.2. Sustainable Mountain Development

2.2.1. Rationale and Justification

In today's world economies, the emphasis of development planning has shifted towards the simultaneous achievement of three major goals. Firstly, in the face of growing population and persisting

poverty, there is a need to ensure some growth of national income. Secondly, the fruit of growth must be widely shared for a frontal attack on social inequalities and endemic poverty. Finally, the growth process should inevitably be sustainable in terms of environmental consideration, self-reliance and domestic resource conservation. Because of low incomes, high poverty levels and precarious resource endowments, the attainment of these goals become highly challenging in the developing countries like Pakistan. It demands that government policies be devised most appropriately, carefully and wisely to ensure a self-propagating and sustainable process of economic development (Vosti and Reardon 1997; Garrett 1998).

Northern Areas are the nation's watersheds and they ensure the supply of irrigation to the Indus plain. The efficient management of watersheds is crucial not only in supply of irrigation water, but more importantly to prevent sedimentation of dams, flooding and landslides because of the great economic costs and threats to the livelihood of the entire nation. The Northern Areas of Pakistan current rate of highest population densities per cultivated hectare, the highest ratio of human to land, and the greatest pressure to use the extreme marginal soils and slopes most intensively require urgent and foremost attention (NCS 1991). Otherwise, not only the people of the region, but the nation at large face enormous and grave consequences.

This region is also the storehouse of the nation's bio-diversity, particularly agriculture and therefore is a valuable site of traditional knowledge of natural resource management. However, these areas are primarily characterized as subsistence oriented, and rely heavily on environmental resources in terms of fuel-wood, fodder, agriculture, etc. for survival. Coupled with the increased pressure on natural resources from population growth, the process of modernization has taken root. State institutions as well as customary regulation arrangements have broken down or become weaker, women have been deprived of their customary rights, and the poor have been increasingly excluded from access to environmental resources. Confronted with the social, economic and environmental dilemmas, emphasis need to be shifted to a more holistic approach to development.

Government takes a direct financial interest in the well being of the mountain farmer, but significantly less interest when it comes to providing funds for watershed management, afforestation and wild life protection. In many cases, particularly for watershed management, the burden of responsibility for wise resource use falls on mountain farmers. They must respond in many ways that not surprisingly go far beyond improved agricultural management: stabilizing soils, cultivating new 'niche' crops dependent on special soils and markets, and encouraging the young who can not find local jobs to migrate to the plains or beyond. Attention, by the government, also needs to be focussed on mountain specificities, namely inaccessibility, fragility, marginality, diversity, niche/comparative advantage and adaptation experiences. An integrated approach in which diversity of the local economy along with intensive agricultural development are part of the equation and perhaps the key to this region.

Lastly, it is opportune time to incorporate and develop the area in accordance with sustainable agriculture based rural livelihood. Currently, there is a steady flow of environmental projects, including Northern Areas Conservation Strategy, in this region. And with the realm of these forestry, watershed, bio-diversity projects, sustainable development can be incorporated and developed on conceptual, strategic and practical levels.

Pakistan's historical experimentation in rural development approaches had inevitably failed. Part of the problem had been ineffective and transparent implementation of strategies. Yet another level problems have been in the realm of appropriateness of strategies to the social, economic, political and cultural factors. Some of the integrated rural development attempts were reviewed to elicit lessons from history that NGOs/Projects have learned and built on (Chudhry et al. 1998). These include the Village AID Program, the Basic Democracy System and the Integrated Rural Development Program.

2.2.2. Aga Khan Rural Support Program

The onset of the military rule in 1978 also signaled the end of the populist movement in the 70s in Pakistan. Since 1980, Pakistan began what is known as the first phase of World Bank/IMF Structural Adjustment Programs. This required privatization, deregulation and economic liberalization of the national economy. Through shrinkage of the government, room was created for the private sector and non-governmental organizations to take up the role of development. It is inline with the new framework that the Aga Khan Rural Support Program (AKRSP) initiated its work in the Northern Mountainous Areas of Pakistan's in 1982. The objective was to increase the capacity of the people so that they become involved in their own development to improve their income and welfare in a sustainable and equitable manner. AKRSP had so far organized more than 2600 rural communities in to village/women organizations with 101,300 members, who generated Rs. 210 million as their collective savings and trained nearly 13200 village level specialists in managerial and technical disciplines. Within Pakistan, a number of rural support programs are now following the conceptual model evolved by the AKRSP.

Agriculture Section of AKRSP led the process of integration in response to the issues of natural resource management at the village level. The focus on social forestry and watershed management is getting more acceptances both by the AKRSP staff and the rural communities. It has developed a "Women Catalysts in Environmental Change" package for the establishment of backyard fruit and forest nurseries.

2.2.3. Kalam Integrated Development Project

Kalam Integrated Development Project (KIDP) is an area development project, covering the whole of Kalam and Bahrain tehsils in the north of Swat. KIDP started in 1981 as a forestry project completed in 1998 under four phases. The main objective of the project is to improve the socio-economic conditions of population in the project area through people participation in forestry, agriculture and village development, taking in to consideration the ecological, social, economic and institutional sustainability of all means and activities at all levels. The project also helped to create, support and strengthen participatory VOs to the point that they can assert their due right and avail resources from government and non-government institutions. The other objective was to bridge service delivery between VOs and government and non-government programs; accustom all programs to working with and delivering services to VOs. The project has some success in increasing farmer's income through introduction of short-term interventions especially the off-season vegetables.

2.2.4. PATA Project

PATA project was focussed on an integrated approach to agricultural development. The project was a joint venture of the government of NWFP and the Kingdom of the Netherlands since 1989, and it was phased out in June 1996. PATA project follows a bottom up approach of agricultural development. The Agricultural Development Program followed an integrated approach of farming system development, client oriented and agricultural extension aiming at increasing agricultural production. The Land and Water program aiming at the development and protection of resources for optimal agricultural use. The Women in Development program established and integrated activities especially geared to address and solve the problems and constraints faced by female farmers (PATA 1996).

Water development schemes of PATA have created substantial opportunities for growing of potato and other vegetables in the area. Since operation and maintenance costs of these schemes are borne by the farmers, a change towards growing of cash crops to cover these costs seems essential. Hence, both spring potatoes and autumn potatoes have emerged as potentially profitable crops for the local farmers. Similarly, over the last few years, the area under tomato crop has increased considerably. At present, most of the farmers consider tomatoes as a cash crop of very high importance, and during the Kharif many farmers would have 30 percent to 100 percent of their cultivated area under tomatoes. Onion has become another most important cash crop in the PATA region and area under onion cultivation has been more than doubled.

Two key factors contributed to the success of the project have been the training of farmers in growing improved seed of wheat and maize crops, and especially building the capacity of Agricultural Extension Department in the participatory approach to agricultural development.

2.2.5. Malakand Fruit and Vegetable Development Project

Malakand Fruit and Vegetable Development Project (MFVDP) is another joint venture of Pakistan government with Swiss government. The goal is to improve the income of small farmers by supporting their fruit and vegetable related activities. The MFVDP has, since 1988, developed innovative approaches to pilot development work in horticulture using the Project Venture approach, has initiated a range of development activities in the Malakand Division with the aim of understanding the marketing system, identifying marketing opportunities, and promoting production and marketing systems in the private sector to exploit such opportunities. It has, moreover, considerably strengthened the Agricultural Station, North, Mingora with training, equipment, infrastructure, mobility and more importantly a participatory approach to development.

At a more general level, it has been argued that policies that encourage broad-based improvement in rural incomes and employment are most likely to lead to a greater willingness and ability on the part of the farmers to conserve resources. These might include macro-economic policies, agricultural sector policies, policies that improve capital markets, and policies that support agricultural research and extension. Increased food production and income opportunities in high potential areas can also result in less pressure to abuse fragile and marginal areas.

2.2.6. Shinkiari Tea Research and Development Programme

In 1984, Pakistan Agricultural Research Council in collaboration with the Chinese experts identified around 150,000 acres suitable for the plantation of tea in Pakistan. The promising Chinese varieties suitable for Pakistani conditions were also selected after field-testing. A pioneering tea plantation at Shinkiari on an area of 33 acres was developed in 1986. The tea plantation is the most suitable and economic intervention for watershed management. The development project to introduce tea in Hazara and Swat was initiated during 1998. Recently, the President of the Islamic Republic of Pakistan inaugurated the black tea processing plant.

The major reason for the slow introduction of tea in Pakistan is the long gestation period of seven years, when the investment equals the returns. Thus farmers need support for the livelihood, as their landholdings are very small. Furthermore, replacement of wheat and maize with tea is not practical due to the reason that resource-poor farmers need continued income for their livelihood. Thus there is a need to revise the strategy of tea cultivation in Pakistan by assigning high priority to tea introduction as a watershed plant. Therefore, concept of tea as hedgerow may be introduced.

2.3. Impact Assessment and Target Group Analysis of Selected Programs and Projects

After reviewing the participatory impact assessment and target group analysis of selected programs and projects, few cases are selected considering the core elements emerged from this exercise. This includes both the programs and projects implemented under the governmental and non-governmental set up.

2.3.1. Impact of Mangla Watershed Management Program

Ahmad and Ahmad (1999) conducted an impact study of the Mangla watershed management program by selecting three catchments of Misa-Kiswal, Kahuta and Kotly Sattian to represent the wide variability of soil, topography, altitude, land forms, climate and cropping practices prevailing in the area. Soil erosion and loss of top fertile soil still the major issues affecting the productivity of these catchments. Farmers in these catchments are engaged mainly in subsistence agriculture and they supplement their income from off-

farm sources. Women are generally engaged in bringing drinking water from springs/wells, collecting fuel wood, raising poultry, looking after livestock, and harnessing crops – especially groundnut and vegetables. A multi-disciplinary team was constituted to conduct a diagnostic analysis in the three selected catchments. A participatory approach was used with the communities, in which 5 to 15 farmers participated at each location. The data and information collected through PRA and diagnostic analysis were used to outline the impact.

The indicators used are: a) changes in productivity; b) changes in resource degradation; c) changes in local resilience and vulnerability; d) changes in self-dependence of groups and communities; and e) replication and operational procedures.

Changes in productivity: In all the three catchments there were substantial changes to productivity. Crop yields of maize, wheat, sorghum and groundnut has improved, along with biomass productivity. There are more trees on farms, and land values have increased, especially where there has been conservation. The increase in labor rates is due mainly to out-migration of labor in the past 10 years. There is heavy dependence on off-farm income, with many people serving in the army and civil service.

Changes in resource degradation: The main changes that have affected resource degradation include the adoption of land terracing with local grass planted on the bunds, land leveling with trees on boundaries, water disposal outlets and land reclamation. Many non-adopters of technologies could not afford the cost of machinery, even though there is a government subsidy of 50 % of the structural costs of water disposal outlets and erosion control structures. Groundwater level has increased in all the three catchments due to better retention of rainwater, although the best improvement is in Misa-Kiswal. A few resource rich farmers are installing dugwells with diesel operated pumping sets.

Changes in local resilience and vulnerability: The major source of income in all the three catchments was livestock, wheat and maize. Due to diversification, farmers are now earning more income from pulses, groundnut, fuel/timber, vegetables and fruits. Farmers in Misa-Kiswal were aware of monthly meetings of extension agents and routine training activities of the Provincial Extension Department. Although credit facilities from banks are available, farmers are reluctant to take credit in all the catchments.

Changes in self-dependence of groups and communities: No evidence exists in any of the catchments have sustained community or group activity. However, communities do response to efforts organized to consider their interests; for example, forest plantations, rodent control, etc. There is no improvement in group or community co-operative actions. There are no committees or farmers organizations for co-operative action in any of the catchments. There is no concerted effort made by the project authorities towards integrated catchment development, and farmers are supposed to visit 10 to 13 line departments for information or assistance.

Replication and operational procedures: There is some awareness of the watershed management activities in neighboring catchments, and some farmers in these catchments are terracing their lands, planting eucalyptus on field boundaries, using better seeds of wheat and maize, and using fertilizers. However, there is no integrated development approach in these areas, and only individuals do the replication. It is only recently that a participatory catchment approach has been appreciated as an option for departments.

A major limitation is the lack of training for line department scientists/engineers and beneficiaries in integrated planning, design, implementation and monitoring/evaluation. The other shortcoming is the lack of a participatory approach. Radio and television helped to engage the community to adopt new interventions and the media played a significant role in the dissemination of technology.

The current approach lacks analysis between inputs, outputs and impacts. Most of the projects were designed using input/output concepts. The impact is directly related to attitudinal changes within the community. There is a need to use social and civic initiatives as an entry point, followed by productivity

enhancement and income generation activities, and resource management interventions through a well-integrated strategy.

2.3.2. Target Group Analysis of Tarbela-Mangla Watershed Management Program/Project Impacts

The World Food Program and the German Development Bank, Kreditanstalt für Wiederaufbau (KfW), are assisting in the financing of the Tarbela-Mangla Watershed Management Project in Pakistan. A Participatory Target Group analysis was conducted in five villages across all the five watershed divisions of the project area. The aims were to assess the relation of local target group's to forests and natural resources and determine the impact of past afforestations on these groups. The study revealed that there is great variability in biophysical, social, economic and institutional conditions both between and within the villages, so making it imperative that watershed activities vary from site to site and group to group (Pretty et al. 1995).

Social: There was a surprisingly open recognition amongst many project staff and others that the project's current and past approaches to watershed development would not be able to deliver the long-term upland rehabilitation expected in the project. There was also an emerging awareness amongst the Forest Department staff that local people's participation in watershed development activities is essential to the future success of the project – but not yet how this can be done.

Economic: It was found that an awareness amongst local people regarding planting of trees and engaging in watershed rehabilitation was to their benefit – but not yet amongst all sectors of each community.

Ecological: The study revealed that a readiness amongst local people to act collectively for environmental rehabilitation, and there were no evidence that 'conflicts' between Gujjar graziers and settled people will hinder the project if plantations cease to be seen as government owned.

It will be difficult to have success without fundamental changes in the approach. The project needs to be amended to incorporate three critical concepts: better integration of efforts for whole watershed improvement; more participation and mobilization of local people; and greater multi-agency linkages between line agencies, NGOs and local communities. Although these concepts are listed in the project, it does not set out mechanisms and methodologies. There is a need for training of project staff in participatory methodologies and implementing of locally based planning in a limited number of sites. This has to be initiated as the beginning of the process of reform. Also needed is to identify suitable NGO partners and capacity in line agencies; and negotiate an agreement for mechanisms for the new project processes (Pretty et al. 1995).

2.3.3. Impact Assessment of AKRSP

Economic: Since the early 80s, there have been positive impacts on the household income in the Northern Areas. This is associated with expanded employment opportunities for men in local urban centers and in other cities of Pakistan and the Middle East, as well as the increased production and returns from agriculture. AKRSP can certainly claim to have had some impact on the farmer by improving village access, but its major contribution was in agriculture. The higher income has obviously benefited rural families, but the changes have affected the functioning of the household system, with specific effects on women.

AKRSP has significantly enhanced women's economic activities and increased their status in the households. The opportunity for savings, access to credit and training for better resource utilization have been important measures, in addition to the introduction of production packages specifically designed for women. The latter have included vegetables, poultry and nursery interventions, which have the potential to generate income.

An evaluation study of the Vegetable Introduction Package (VIP) was conducted in all three regions among a total of 210 women from 42 WOs. The vegetable production has increased by over 100%, whereas the

marketing of these vegetables has increased the women's income by over 140%. In addition to household consumption, fresh vegetables were marketed locally or in nearby towns. While portions of the unsold crop have been dried and marketed later. More than 50% households have marketed their produce. Income generated was used for education of children, purchase of daily use items, agricultural inputs, and savings in WOs accounts.

The benefits obtained by women have some associated cost. Women and children have assumed a heavy workload in the household system. The changes, which have occurred in off-farm labor, farming enterprise patterns and additional activities encouraged by the Program, have increased the women's workloads (Khan 1989).

In general, with the increase in women's ability to save and access credit, to increase household income or to assist their male relatives effectively has resulted in to an increase in self-confidence. They were also engaged in long-term, group and individual, future planning through scheduled activities of the WOs.

Social: AKRSP has not been directly involved in the social service programs to address health, education and nutrition issues. Most social service interventions pertain to GoP programs with local and external funding and to NGOs, especially Aga Khan Health Service (AKHS) and Aga Khan Education Service (AKES). AKRSP has played an important role, however, in its creation of village institutions, which can facilitate social welfare activities, and in recent years through its promotion of linkages between VOs/WOs and support agencies.

WOs have been actively involved with AKHS in training of community health workers and birth attendants, largely in Gilgit and Chitral and in linkages with GoP programs for immunization and control of iodine deficiency. AKRSP has also cooperated with GoP in its Social Action Program (SAP), which was linked with VOs to provide water distribution schemes.

A direct impact by AKRSP has been in improving nutrition, which affects both health and productivity. Members of WOs are quick to point out nutritional changes, which have occurred in recent years. This particularly applies to increased consumption of vegetables by the introduction of AKRSP's intervention. In addition to the cultivation of traditional vegetables, improved seed and cultural techniques for new types of vegetables were also introduced. Improved poultry production by 80% of WOs has increased the intake of animal protein by the locals.

Education is essential for the improvement of community productivity and welfare as well as the younger generation if they are to benefit from the expanded opportunities created by economic development in the area. AKRSP has recently coordinated with GoP's SAP in primary education, where VOs actively participated in the establishment and maintenance of community schools.

Ecological: The approach has yielded results, as large tracts of wastelands were reclaimed. Afforestation was carried out on old and new lands. Farm forestry is now widely practiced. The highly integrated and complex nature of farming systems in the Northern Areas coupled with the changing socio-economic conditions of the region (rapid population growth, multiple uses of cultivated land and emergence of alternative economic opportunities), have led to changes in management of natural resources. AKRSP has experienced a program shift from isolated sectoral activities to the creation of a Natural Resource Management program, in order to implement a sustainable and integrated strategy for conservation. This has led to the implementation of eight pilot projects in which VOs/WOs participated in integrated planning, resource appraisal and integrated extension thereby undertaking agriculture, livestock and forestry activities in an integrated manner. The program also emphasizes the use of local knowledge to find better solutions for sustainable management of available resources.

2.3.4. Impact Assessment of PATA Project

Economic: The welfare of more than half of the farmers has increased due to agriculture. The yields of major crops in the project area have gone up by 25% compared to the impact survey conducted in 1993. The irrigation schemes developed for the farmers provided a high rate of return of over 110%. Yield increases could be attributed to a higher number and effective contacts between extension agents and farmers and to a higher adoption rate of the PATA recommendations. Women are actively involved in the Scheme Development Process to ensure viability of washing places, options for growing of high value crops and fodder production for livestock.

Social: The Scheme Development Process has increased the participation of water user groups in the development and maintenance of the irrigation schemes. Farmers are managing the schemes themselves to use the irrigation water for the production of high value crops. Women participation in agricultural development was increased, thus facilitating interaction with the project staff. Increase in the gender knowledge of the male project staff helped to better address these issues in the process of development.

Ecological: The use of integrated pest management on the promotion of sound cultural practices as preventive measures, rather than simply the use of chemicals as curative measures (such as optimal planting distance, balanced fertilizer recommendation, etc.), have been found to be more environmentally sustainable and effective. The introduction of mott grass and other fodder for crucial months in the summer and winter seasons were effective to alleviate overgrazing pressures on hillsides, thus resulted in promotion of fodder regeneration.

2.3.5. Impact Assessment of Kalam Integrated Development Project

Economic: Economically substantial increase in income has been brought out by the successful promotion of alternate sources of income, in particular the sale of off-season vegetables and horticulture crops plays an important role. The project had effective co-ordination with the MFVDP and NARC Islamabad. The NARC Vegetables Research Program helped the project staff to introduce cultivation of off-season turnips, peas and other vegetables. The communities were able to sell their produce in Rawalpindi/Islamabad at a premium price. The proceeds from the sale of timber (60% going to the local community) have been instrumental in increased livelihood earnings.

Social: The interest groups formed in the area were instrumental in seeking support for inputs and information for marketing. Farmers built and manage the irrigation schemes themselves to use the irrigation water for the production of high value crops. Women participation in agricultural development was increased, thus facilitating interaction with the project staff. Increase in the gender knowledge of the male project staff helped to better address these issues.

Ecological: The increased and intensive surface cover especially in the summer season helped to reduce surface runoff and sediment load to the river streams. However, the introduction of off-season vegetables would result in increased use of chemical fertilizers and pesticides having a danger for polluting the surface waters. Thus the increased income in the watershed areas has to be linked with environmental pollution. There has been some awareness to strengthen the livestock production system to have self-sufficiency in organic manures. Ultimately, organic farming has to be introduced in these areas.

2.3.6. Impact Assessment of Malakand Fruit and Vegetable Development Project

Economic: NWFP with its special physiographic conditions and small land holdings offers the most opportune environment for the development of high value agricultural pursuits commensurate with its natural endowments. Impact on agricultural economy has been tremendous, especially in accordance with project

objectives for developing potential in the area of horticulture. Increased production and the off-season nature of production have substantially contributed to returns to farmers. Benefit of increased productivity of horticulture especially in the case of vegetables, mainly, benefited the small- and medium-sized farmers. Traders and other intermediaries are getting involved in horticultural related activities. These developments are producing a budding private enterprise in fruit and vegetable plant nurseries, crop chemicals and other input/output related services.

Social: The project helped to alleviate the social disparities among the rural communities.

Ecological: The project with its 16 ventures and seven programs have embarked on market and farmer oriented, ecologically sound research activities in all the five locales. The ventures include nine enterprises, two services and five extension interventions. The Programs include Management/Strategy Unit, Integrated Pest Management, Post- Production Technology Unit, Kalam Summer Station, Agro-economic Unit, Technology Transmission Unit and Pilot Application Units.

Collaborative linkages have been established with other projects and programs operating in the Division as also with renowned institutions such as the NWFP Agricultural University with its Education and Research Wings, Pakistan Agricultural Research Council, International Institute for Biological Control at Rawalpindi and Natural Resources Institute of UK. The IPM program helped to integrate possible management techniques like cultural, biological, mechanical, physical and chemical practices for the control of pests. However, still a practical strategy and interventions are required for IPM on sustainable basis.

3. Issues

Lessons from the success stories certainly depict key insights for the watershed management technological, social, policy and institutional alternatives. The integrated approach practiced under the watershed management and rural development projects/programs in the country highlights the need for a holistic strategy to watershed management. The proposed comprehensive strategy would balance the sources of conflicts among social, economic and environmental factors affecting production sectors and conservation needs of agriculture, livestock, forestry, etc. This complex of social, economic and environmental factors present key elements emanating from the stories of success are: institutions; sustainable food, timber and fuel-wood production; equity; gender; resource conserving technologies; and linkages to the local economy. The lessons learnt and issues confronting the watersheds in Pakistan are:

- Ø There is a need to create, support and strengthen participatory local institutions at the grass-root level to the point that they can assert their due right (particularly in planning, implementing and monitoring interventions) and avail resources from governmental and non-governmental donors' institutions, increase their capacity and bargaining power, and committed to serve to maintain ecological balance;
- Ø In the process of empowering the local communities during the 20th century, the assumption was that once these communities are strengthened, they would put pressure on the line departments to change their attitude. In fact, during the last two decades these institutions have deteriorated to an extent that they now require major reorientation for effective response to the enlightened communities. There is a strong need to reposition the attitude of the line departments and public institutions from authority to service and at the same time to further build their capacity to make them more responsive to the changing needs of the local communities. The line departments like Agriculture, Forestry, Livestock, Education and Health - and other government agencies and programs have to support sustainable watershed management with active partnership with the grass-root level NGOs;
- Ø Twinning and networking of local community institutions with service/inputs delivery institutions; and networking of various programs working with local institutions for delivery of services or technologies;
- Ø Development of appropriate and cost-effective technologies, practices and methodologies is required for both production and managerial aspects. Transfer of information and skills have to be linked with

- credit delivery services of the NGOs;
- Ø Grafting of local and technical knowledge is compulsory to forge viable and site-specific technologies and solutions to watershed management problems;
- Ø There is a need to remain flexible using a program approach instead of a project approach through periodic monitoring and evaluation. In addition, an iterative planning process has to be reformed to achieve impacts of program interventions;
- Ø Equity in the delivery of goods and services, particularly to the resource poor families and especially women, from various external institutions will ensure broad-based participation and benefits accruing to maximum number of participants.
- Ø There is a need to recognize the role of men and women in economic and social arrangements, and whether they deprive, or not take into account, women's access to or rights over natural resources.

4. Recommendations

Success of watershed programs depends on the optimal blend of social, economic, ecological, political and site-specific realities through active participation of local communities in the appraisal, planning, financing, implementation, monitoring and evaluation of projects/programs. The project approach is too much focussed on targets and there is a need for rethinking to adapt a program approach. However, within the framework of the program approach, various activities can be projectized for the purpose of funding.

We have already over-emphasized the bottom up approach, whereas the line departments are still in the realm of top-down approach. There is a need to have a blend in the form of a balance-approach (middle-approach), where both the line departments and the grass-root level communities are responsive to each other with clear-cut roles, responsibilities and rights. Otherwise, if the bottom-up approach is continued without repositioning of the role of the line departments from authority to service, there is a danger for another failure. This will be a colossal loss to the country.

Watershed problems are mainly of management and social, whereas we are looking it merely from the technological end. There is an urgent need to upgrade the capacities of the local communities and the line departments for conduct of joint diagnostic analysis and ranking of real issues and interventions. The financial resources will be always short for watershed management, therefore, a phasewise approach is recommended where most sensitive reaches have to be treated having more enlightened communities. Furthermore, watershed management should not be considered as a project outside the routine activities of the line departments and the local communities.

Primarily, the Forestry departments of the four provinces are carrying out the watershed management projects in collaboration with the Water and Power Development Authority (WAPDA). However, in last two decades several agencies emerged which are at present involved in watershed management research and development activities on diversified resources of watershed areas. There is a need to have networking of these institutions because no single agency can handle all the issues related to watershed management.

The interventions for watershed management should be selected in a way that these interventions provide income to the farmers. The successful introduction of tea as cultivated plant demands that it must be considered as a watershed plant. This will also avoid the problem of replacing wheat and maize with tea, which is not practical due to the reason that resource-poor farmers need continued income for their livelihood. Thus there is a need to revise the strategy of tea cultivation in Pakistan by assigning high priority to tea introduction as a watershed plant. Therefore, concept of tea as hedgerow may be introduced. Once the income is started from the hedgerow plantations, the farmers will be having confidence to introduce tea as cultivated plantations. All the suitable area of tea plantations is within the catchment area of Swat and Siran rivers draining water to Tarbela Lake.

5. References

1. Ahmad, N. and S.D. Pervaz. 1963. Soil erosion in the northern region of West Pakistan. *Pak. Journal of Forestry*. 13(3): 291-295.
2. Ahmad, S. 1993. Viability of agriculture resource base: A critical appraisal. In: *Agricultural Strategies in the 1990's: Issues and options*. Pakistan Association of Agricultural Social Scientists, Islamabad.
3. Ahmad, S. and J. Ahmad. 1999. The impact of Mangla watershed management project, Pakistan. In: *Fertile Ground; The impacts of participatory watershed management*. Intermediate Technology Publications Ltd., International Institute for Environment and Development, London, UK.
4. Akram. R.M. 1968. Mangla watershed management, Kanshi and Poonch river catchment. First West Pakistan Watershed Management Conference, Pakistan Forest Institute, Peshawar.
5. Ali, A.A. 1990. Whose forest is it anyway? *The Herald*, Karachi, January.
6. Ashraf, M.M. 1987. The role of forestry in watershed management and soil conservation. *Journal of Forestry*.
7. Chaudhry, M.G., U. Iftikhar, S. Zia and J. Ahmad. 1998. Policies that work for sustainable agriculture and regenerating rural economies. *Pakistan Country Study*. IUCN and SDPI, Islamabad.
8. DAI, Harza and NESPAK. 1988. Master plan for Barani area development. Vol. III. Water Resource Development. Development Alternatives, Inc., Harza Engineering Company and National Engineering Services of Pakistan.
9. DSC 1994. Soil conservation. Field Office Technical Guides and System Performance Criteria. Directorate of Soil Conservation, Government of Punjab, Rawalpindi.
10. Garretti, J.L. 1998. Challenges to the 2020 vision for Latin America: Food and Agriculture since 1970. *A 2020 Vision for Food, Agriculture and Environment*.
11. GOP. 1992. Pakistan national report to UNCED. Ministry of Environment and Urban Affairs, Government of Pakistan.
12. Gorrie, R.M. 1946. Soil and water conservation in the Punjab. Progressive Books, Lahore
13. Hanif, M. 1988. Comparative hydrological studies of watershed treatment at Chikar, Azad Jammu and Kashmir. Annual Progress Report. Pakistan Forest Institute, Peshawar.
14. Hanif, M. 1992. Comparative watershed to study surface runoff and sediment yield at Missa. Annual Progress Report, Pakistan Forest Institute, Peshawar.
15. IFAD. 1992. Barani area village outreach project. Specific Identification Report. Asia Division, Project Management Department, Rome Italy.
16. Ishaq, C.M. 1968. Mangla dam watershed management - outline of planning and execution problems experienced. First West Pakistan Watershed Management Conference, Pakistan Forest Institute, Peshawar.
17. Khan, Y.M. 1989. People participation in upland conservation in NWFP, Pakistan. *Pak. Journal of Forestry*. 39(2): 63-69.
18. Minissale, G. 1991. Plunder in the hills. *The Herald*, Karachi, February.
19. Mohtadullah, K., C. Ata-ur-Rehman, and C.M. Munir. 1991. Water for the 21st century. Special paper for the Pakistan National Conservation Strategy. Ministry of Environment and Urban Affairs and the World Conservation Union.
20. NCS. 1991. National conservation strategy. Government of Pakistan, Ministry of Environment and Urban Affairs, The World Conservation Union.
21. PATA. 1996. Impact of the Agriculture Development Program. PATA Integrated Agricultural Development Project, Saidu Sharif, Swat. PATA Publication No. 112.
22. PARC. 1986. Management of gully eroded areas in Pakistan. Pakistan Agricultural Research Council, Islamabad.
23. Pretty, J.N., J. Ahmad, H. Malik, N.A. Malik, S. Ahmad and T. Rehman. 1995. Participatory target group analysis for the Tarbela-Mangla watershed management project, NWFP, Pakistan. Report I: Key findings and recommendations. International Institute for Environment and Development, London, UK.

24. Punjab Act II. 1900. Punjab land preservation act of 1900. Government of Punjab.
25. PWP. 1999. Watershed management. In: National Workshop to Formulate Pakistan Water Vision. Global Water Partnership, Pakistan Water Partnership and Swiss International Development Agency, 24-25 May, Best Western Hotel, Islamabad.
26. Saeed, K.A. 1974. Watershed management and the Mangla watershed project. National Seminar on Ecology, Environment and Afforestation. Urban Affairs Division. Islamabad. p. 94-95.
27. Shah, S.A. 1989. Closing remarks of the opening ceremony of the international seminar on Pakistan forest policy. Inspector General of Forests, Islamabad.
28. Shah, B.H. 1991. Effect of soil conservation measures on sediment yield in Azad Jammu and Kashmir. Annual Progress Report. Pakistan Forest Institute, Peshawar.
29. Subhan, F. 1985. Evaluation of hydrologic performance of soil conservation measures on comparative watersheds in the sub-tropical scrub zone. Annual Technical Report. Pakistan Forest Institute, Peshawar.
30. Vosti, S.A. and T. Reardon. 1997. Sustainability, growth, and poverty alleviation: A policy and agro-ecological perspective. International Food Policy Research Institute, Washington, USA.
31. WASID. 1967. Sedimentation appraisal report. WAPDA, Lahore.
32. WAPDA. 1986. Siltation in reservoirs. Water Resources Management Directorate, Lahore.
33. WRRI. 1995. Participatory research and development. Fatehjang Field Station. Water Resources Research Institute, National Agricultural Research Center, Islamabad.
34. WRRI. 1997. Initial technical diagnostic surveys for Mirwal and Shahpur dams in Pothwar Plateau. Water Resources Research Institute, National Agricultural Research Center, Islamabad.
35. WRRI. NARC. Unpublished sediment load data of Rawal Watershed of Satrameel.
- 36. WSIPS. 1990. Water sector investment planning study. WAPDA, UNDP, World Bank, Sir M. MacDonald and Partners, Harza Eng. Co. Int., Nespak, ACE, Lahore.**