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Drainage and Environment Evaluation of Past Interventions and Future Strategies in Pakistan

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DRAINAGE AND ENVIRONMENT EVALUATION OF PAST INTERVENTIONS AND FUTURE STRATEGIES IN PAKISTAN

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INTRODUCTION

Lack of adequate drainage has probably been the greatest single cause of failure of irrigation projects throughout the world. History has repeatedly shown that excess water and salt must be removed from soils for long-term sustainability of the irrigated agriculture. Therefore, if irrigation is considered to be the science of survival of mankind, drainage undoubtedly provides for the survival of irrigation.

The main objective of land drainage is to remove excess water in order to improve the profitability of farming the land. The need for drainage in humid and semi-arid regions stems from basically different requirements. In humid areas, an effective drainage system prevents waterlogging by removing excess rainfall and ensures easy and early access to the fields for carrying out agricultural activities. The main objectives of a drainage system in semi-arid regions, on the other hand, are to control the water table and maintain the soil salinity in the root zone within acceptable limits for optimizing crop yields.

Ever since the introduction of the gravity flow irrigation system in Indus Basin during the later half of the 19th century, the seepage of canal water into the sub soil strata has been a continuous process. Mostly a flat topography with only a small gradient available for the natural drainage and inefficient irrigation practices caused rise in the ground water table to alarming levels. This produced major environmental problems of waterlogging and salinity in the irrigated areas.

In the late 1950, the Government of Pakistan launched comprehensive plan to control the twin menace of waterlogging and salinity through a series of Salinity Control and Reclamation Projects (SCARPs). The construction of the surface drainage system under these projects not only catered for storm run off but also provided for evacuation of excess water from the low lying areas. These projects were successful in lowering the ground water table beyond the root zone, supplementing the irrigation supplies from canals but the associated O&M costs were very high. Another major environmental issue has been the pumpage of marginal quality groundwater, which is adding a secondary salinity to the irrigated areas, particularly the tail ends of the system.

Pakistan has all the essential resources to become one of the leading agricultural country of the world provided the hazards of waterlogging and salinity are checked. The situation has become very critical for economy of the country because of the rapidly growing population and stagnating agricultural production. There is thus urgent need to develop a framework for integrated management of the water resources and to evolve the quick sustainable interventions for environmental protection.

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POSSIBLE ENVIRONMENTAL IMPACTS OF DRAINAGE PROJECTS

Drainage projects always have a substantial effect on the environment of the area where they are located, and a forecast should be made of the environmental impacts expected to occur. The study should note possible adverse environmental effects, assess their seriousness, and weigh the extent to which other benefits will compensate for them. In particular, the effect of the drainage effluent on downstream water use and on downstream ecology should be considered.

The impacts of drainage are well known, such as increased agricultural production that results in the generation of income and food import substitution. In addition to the intended impacts, however, other unintended effects that constitute a future problem may arise if these effects are not addressed properly during the planning stage of the project cycle. When done properly, drainage planning leads to efficient drainage systems that will bring about only the positive intended impacts. The objective of drainage environmental assessment during drainage planning is to compile information and to prepare check list for the decision maker, who can use it in taking decisions about project implementation, which may include :

- choosing the suitable environmental assessment method during drainage planning and implementing the project as proposed

- taking precautions and selecting design measures to prevent or mitigate the unintended undesirable environmental effects

- choosing an alternative development plan that achieves approximately the same intended objectives with a less adverse environmental effects, and

- evolving a project design that is sustainable in the context of prevailing field conditions.

The effects of drainage on the environment are diverse and they depend on the stage of drainage improvements. The impacts of drainage improvements cannot be easily measured, because they are scattered within the catchments. As a result, drainage construction may last for years in a given catchment; in these conditions the changes are in general continuous and difficult to measure. The drainage projects are related with the improvement in water quality and checking the degradation of land. The effectiveness of drainage project may depend on the level of performance of various components and in some cases desirable positive impacts may not be achieved due to sub-optimal performance of a single component, such as inadequate effluent disposal or unfavorable outfall conditions, etc. The impacts of drainage cannot be easily distinguished from the associated changes of agricultural practices: drainage improvements go most of the time hand in hand with changes in the farming systems. To make the investment profitable, the farmer has to take account of the improvements of its soil conditions after drainage construction. The farmer will, therefore, adopt his farming practices to the new situation. But the adjustment may take time and a better control of the efficiency of his production inputs will not be achieved at once (Zimmer and Needlec, 1995).

In predicting environmental effects of drainage projects, attention should be given to the following (Ritzema, 1994) :

- direct and indirect effects, or first order and higher order effects. There are chains of effects, such as draining the upstream part of a river catchment, change in river hydrology, change in the environment of a downstream floodplain, change in ecosystem (agriculture, fishery) and in wildlife habitat;

- secondary effects. The primary activity of a drainage project may be extended to in secondary activities, such as industry for processing agricultural products, which in turn will have certain environmental effects (e.g., polluted waste-water); and

- synergetic effects. These effects include an increased threat to the survival of certain species of wildlife that are under pressure in several ways as a result of the same project, e.g., reduction in available area and degradation of biota through changes in river hydrology and degradation of water quality.

DRAINAGE PROBLEMS OF PAKISTAN AND PAST INTERVENTIONS

Perspective and Early Measures

Before the construction of extensive canal system, the groundwater table in Indus Basin was in the state of natural equilibrium. The water table was quite deep, ranging from 50 to 100 feet below ground level in different parts of the country. The groundwater level fluctuated during the annual hydrological cycle; it used to rise as a result of the monsoon rains, but would return to the normal levels during winter season as a result of natural drainage.

Indus Basin Irrigation system was initially developed without provision for drainage. Extensive irrigation without adequate drainage in the alluvial soils of Indus plain disturbed the natural equilibrium, as percolation from the unlined canals, watercourses and inefficient field application practices started to build up the recharge. As such, the groundwater table started to rise gradually. In order to monitor the phenomenon, a network of observation points was developed beginning 1870 and a schedule of their bi-annual observations was adopted. The rate of rise of water table varied from 0.5 to 1.5ft per year depending upon the local environment.

The need for drainage investigations were realized for the first time in 1918 when a Drainage Board was created. In 1925, a Waterlogging Enquiry Committee was constituted to advise the Government on the issue, which was replaced by a Waterlogging Board in 1928. First Drainage Circle was established in 1932 and construction of seepage and seepage-cum-storm-water drains was started in Chaj and Rachna Doabs in 1933. After Independence, two Drainage Circles were created in 1951. On the basis of the groundwater levels, various remedial measures were tried. These included closure of canals in monsoon season, construction of seepage-cum-storm water drains in waterlogged areas, lowering the full supply level of canals, planting of phreatophytes along canals, and installation of tubewells along major canals to intercept canal seepage. However, none of these measures provided more than local or temporary relief and the regional problem of waterlogging and salinity continued to increase in severity.

Implementation of SCARPs

After independence of the country in 1947, the Government of Pakistan took serious note of the drainage problems and decided to seek advice from international experts for its solution. Experts from FAO and USA were called to study the problem. In 1954 the government started a program of large scale groundwater and soil investigations with the help of the US International Cooperation Administration (ICA). Investigations in the Lower Indus Plain were carried out by M/S Sir MacDonald & Partners and Hunting Technical Services.

Based on the results of the investigations, WAPDA developed a program of construction of Salinity Control and Reclamation Projects (SCARPs) in 1961. It involved the provision of vertical drainage to large areas. The essential feature of the SCARPs was a network of tubewells located with an average density of one per square mile, in addition to the construction of surface drainage network in the hazardous areas. Where the groundwater was pumped and was of good quality, it was used for irrigation purposes to supplement the canal supplies. In areas, where the quality of groundwater was unsatisfactory, the drainage effluent was discharged into water bodies. The pumping rate of each well was determined by the sub-surface drainage requirements of the areas.

Development of Private Tubewells

The beneficial use of tubewell water for irrigation in the SCARP areas located in Fresh Ground Water (FGW) zone had a demonstration effect. As a result, the installation of private tubewells has come up dramatically since 1960s and presently, there are over about 400,000 small capacity private tubewells in the country. While primarily installed for supplementing canal irrigation supplies, these tubewells contribute to sub-surface drainage also. In fact, most of the FGW areas in Punjab are over-drained and the private tubewells, although running at a low utilization factor, are resulting in progressive lowering of the water tables. The private sector is effectively participating in drainage of FGW areas, thus obviating the need of subsurface drainage and public sector investments in FGW areas.

The Existing Drainage Facilities

The summary of existing drainage facilities is presented in Table 1 (NESPAK et al, 1995).

Table 1
Existing Drainage Facilities

Province	Surface Drains (km)	Subsurface Drainage				
		Tubewells (Nos)			Tile Drains (Acres)	Interceptor Drains (Km)
		FGW	SGW	ScW*		
Punjab	7326	8065	1985	-	130,000	-
Sindh	5980	4161	365	376	45,000	561
NWFP	1990	491	-	-	3,77,000	-
Balochistan	160	-	-	-	-	
Total	14,456	12,717	2350	376	5,52,000	561

* ScW - Scavenger Tubewell

ENVIRONMENTAL IMPACTS OF INADEQUATE DRAINAGE FACILITIES IN PAKISTAN

Waterlogging and Salinity

Any irrigation without adequate drainage in an environment like the Indus Basin has inevitably to lead to rising water tables and salinity. Increase in the diversion of river flows for irrigation, seepage from canals, watercourses, and irrigated areas have resulted in a progressive rise of the groundwater table. Despite the implementation of a number of drainage projects, over 30 percent of the gross commanded area in the country is waterlogged and about 14 percent is considered highly waterlogged. Although irrigation water is relatively free of salts, repeated irrigations and the rise in the water tables has been mobilizing the dissolved salts resulting in build-up of salinity. It is estimated that about 6 percent of the gross canal commanded area is severely salt-affected and another 8 percent is moderately affected.

The impact of salinity on agricultural productivity is severe: a 25 percent reduction in the production of Pakistan's major crops is attributed to soil salinity alone. In Sindh Province, where the problem is much more severe and the experts estimate that this reduction may be closer to 40-60 percent in SGW areas. The critical threshold at which salinity begins to affect the productivity of agricultural land varies with the crop and salt tolerance limits. The impact of waterlogging on yields is also startling. As the depth to water table decreases to within 5 feet, yields of all major crops begin to decline rapidly. At 0 to 0.8 feet depth to water table, declined yields are 2 percent for cotton, 9 percent for sugarcane, and 21 percent for wheat. In addition, there are serious environmental and social impacts associated with waterlogging and salinity (World Bank, 1996).

It has also been observed that in areas located at the tails of distributaries and where canal supplies are limited, groundwater of marginal quality is being used for irrigation in large quantities.

Continuation of this practice over extended periods of time is giving rise to secondary salinization and surface sodicity. This has serious implications for sustainability of irrigated agriculture.

Salt Imbalance

In arid and semi-arid regions, the greatest threat to the sustainability of irrigated agriculture comes from accumulation of salts in the soils. Under ideal conditions the salts must be removed from an irrigation system at the same rate at which they are added to the system. If this does not happen, the salinity in the soils and in the aquifer will continue to increase and it is only a matter of time when salinity would exceed the tolerable limits.

Presently about 130 Bm^3 (106 MAF) of water is diverted annually from the rivers into the canals of the Indus Plain for irrigation purposes. This water contains about 28 million ton (mt) of salts, if the average salinity of river water is taken to be 200 ppm. As such 28 mt of salts are being added to the system every year. Except for the LBOD Project, drainage effluent is being recycled within the system in one form or the other (Mohtedullah, 1997).

Disposal of Drainage Effluent

Besides the potential impact of saline drainage effluent on wet lands there is environmental concern about the disposal of saline effluent into the evaporation ponds or back into the river or canal system. Evaporation ponds can in any case, deal with only relatively small amounts of water, especially as evaporation rates tend to reduce as salinity reaches a high concentration. Such ponds are a hazard, particularly when subject to rainfall or storm water inflows which could cause them to overtop or spread. Lateral seepage and the contamination of groundwater and low lying land is another problem. The evaporation ponds located in SCARP VI Project are posing serious hazards to the adjacent areas, and the environmental degradation has been increasing despite implementation of mitigatory measures.

Quality and quantity of drainage effluent which will be generated by the anticipated drainage development is difficult to quantify accurately. However, as drainable surplus for most of irrigated areas had been estimated by WAPDA or its Consultants, an assessment for the quantity and quality of the anticipated drainage effluent has been made, alongwith planned disposal, as depicted in Table 2.

Table 2: Existing and Anticipated Saline Effluent

Area	Quantity (Maf)	Mode of disposal (MAF) Canals Rivers	Ponds	Sea	
A. Existing		*			
Punjab	1.524	0.393	0.638	0.493	-
Sindh/Bal.	0.498	0.514	0.434	--	-
Total	2.472	0.907	1.072	0.493	-

B. Total Anticipated (including existing)

Punjab	2.948	0.606	1.229	1.113]	
				]	6.012
Sindh/Bal.	2.964	0.751	1.174	0.027]	
Total	10.912	1.357	2.403	1.140	6.012

Source: NESPAK et al (1995)

Saline Water Intrusion

Possibilities of saline water intrusion in FGW areas from adjacent SGW areas exist in the Indus Plain because FGW is found near to the rivers and in those areas where rainfalls are heavy, while areas away from these sources of recharge have SGW. Intrusion of saline groundwater in fresh aquifers is also being apprehended due to over-pumpage in many FGW areas.

Pollution of Groundwater

Due to the growing population of the country, extremely poor conditions of the municipal facilities including the disposal of human and other municipal wastes, growing use of fertilizers, pesticides and insecticides in agriculture and disposal of industrial wastes in drains and ponds, the chances of pollution of groundwater has greatly increased.

NATIONAL DRAINAGE STUDIES / POLICIES

RAP and WSIPS Strategies

In the early 1960's, a massive effort to control waterlogging and salinity was undertaken, and the planning and programming studies' culminated in an `Action Plan' covering ten years period (1965-75). These studies were supplemented by later studies under the changing circumstances, and to draw investment plans to cover various periods as indicated below :

- o Revised Action Program (RAP) 1979 to 1990;
- o Water Sector Investment Planning Study (WSIPS), 1990-2000;

Drainage and disposal received little attention in RAP, except for a review of overall salt balance and the requirements for data collection for subsequent evaluation. The main recommendations of RAP included focusing drainage interventions in hazardous areas (water table depths upto 5ft), no further investments for sub-surface drainage in FGW areas, priority implementation of preventive measures in SGW areas, and phased disinvestment of FGW public tubewells. WSIPS however, looked into drainage and disposal problems and their main recommendations were :

- continue the strategies of RAP
- sub-surface drainage should be confined only to `disaster areas' in SGW zones, excluding areas under rice;

- best return for drainage of dry foot crops are obtained with drainage rates of 1.5 mm/d in Sindh (and possibly Southern Punjab), increasing to at least 3-4 mm/d in Central Punjab;
- the disposal of saline drainage effluent poses a more genuine problem. Maximize the disposal of saline effluent to sea either through LBOD and / or dilute it in summer flood flows. Also keep the salinity mobilized by drainage to a minimum.

Drainage Sector Environmental Assessment Study

The Government of Pakistan, in August 1991, undertook a study for the environmental assessment of the irrigation related drainage in the country. This study was funded by the UNDP and managed by the World Bank. M/S NESPAK in association with Mott MacDonald Int. (MMI) carried out the feasibility. The main recommendations of the study are presented hereunder:

- No project that mobilizes salts from deep groundwater aquifers should be undertaken unless such salts can be safely disposed off in the sea;
- No structural drainage interventions in public sector that can reasonably be carried out by the private sector;
- Public sector to confine its subsurface drainage interventions to SGW areas where there is no environmentally acceptable solution for the disposal of drainage effluent;
- Public Sector to concentrate its surface drainage interventions in areas where it is justified by the risk of storm water damage for the irrigation process; and
- Government to give special attention to beneficiary participation in structural and non-structural interventions.

National Drainage Program (NDP)

The Government of Pakistan, in collaboration with the World Bank, Asian Development Bank (ADB) and Overseas Economic Cooperation Fund of Japan (OECF), has planned to launch a major drainage program at the national level. The main objective of National Drainage Program (NDP) is to restore the sustainability of environmentally sound irrigated agriculture by minimizing the drainage surplus and its eventual evacuation to the sea. The program has been designed as a multi-phased investment package, integrating both the structural as well as institutional components. The overall cost of NDP would be around Rs 115 Billion, to be implemented in 3 phases over a period of 25 years.

The first phase of National Drainage Program (NDP-I) has been conceived and planned as an instrument and first step towards setting the stage for introducing Institutional and Policy Reforms, in addition to the Investment Component for physical improvement of drainage network. The estimated cost of NDP-I is $ 785 Million and it would be implemented with the financial assistance of the World Bank ($ 285 M), Asian Development Bank ($ 140 M) and OECF of Japan ($ 100 Million) in 6.5 years (1997-2003). The Investment Component under NDP-I would finance new drainage schemes, rehabilitation and modernization of off-farm and on-farm drainage, modernization of canal commands, and O&M of drainage Projects through performance contracts. The Federal Government, through WAPDA's Water Wing, would have overall responsibility for implementing the Project, while Provincial Irrigation / Agriculture Departments and Farmers Organizations would also be responsible for implementation of selected projects.

PERFORMANCE EVALUATION OF MAJOR DRAINAGE PROJECTS

Public Tubewells

The evaluation of SCARPs has shown that these projects have generally been able to control waterlogging and to provide valuable additional irrigation supplies in the useable groundwater areas, thereby raising the cropping intensities and agricultural production. Their demonstration effect boosted the installation of private tubewells in the useable groundwater areas. The sub-surface drainage provided by tubewells coupled with additional irrigation supplies created an environment for the reclamation of soils by leaching and other reclamation measures.

Despite these benefits, the SCARPs program has fallen short of the expectations of their planners, because it had generally exhibited a cycle of initial success; control of waterlogging, additional irrigation supplies, increase of irrigation intensities, reclamation of lands; followed by decline in the expected benefits due to decrease of tubewell pumping capacity resulting in reappearance of waterlogging, static or declining cropping intensities, closure of tubewells due to intrusion from saline groundwater etc. Besides, the problem of tubewell design and construction, the problem of operation and maintenance and management have also affected the performance of SCARPs. High rate of tubewell deterioration is partly due to deficiencies in design and construction and partly due to inadequate maintenance. Operation of SCARP tubewells has also left much to be desired (Wahab, 1992).

Coupled with the uneven performance of SCARPs another factor is the financial burden, which includes the high operation and maintenance costs of these projects on the public sector resources. Under-funding of these requirements resulted in further deterioration in the performance of the SCARPs. One of the major reasons for this situation is sharp rise in the power tariff. Further, the increase in water revenue is not keeping pace with the increase in operation and maintenance expenditures resulting in higher subsidy requirement. The Government has therefore been forced to disinvest these expensive projects in a phased manner. The project planning and design (deep / large capacity wells) by the foreign consultants, against the advice of local professionals to use shallow / low capacity wells, appears to have been quite sub-optimal when viewed in the long-term sustainability of the projects.

Surface Drains

In order to address the problem of rising groundwater table, the construction of surface drainage was taken up because the natural drainage was inadequate. Most of these drains are seepage - cum - storm water drains. The capacities of surface drains have generally been designed with rule-of-thumb criteria of 1 to 4 cusecs per square mile of the catchment area. The surface drains have been designed to evacuate the excess rain water within 3 to 5 days period.

The review of the operation of surface drains suggests that the designed capacities are lower than normally required for effective drainage, particularly during severe rainfall events. The inadequate capacities of surface drains have been further aggravated by the man-made obstructions: ill-planned construction of roads, embankments, link canals, blockage of natural drainage lines, and lack of adequate cross drainage works. Inadequate maintenance of drains due to consistent shortfall in O&M funding has led to their clogging with sediments and weeds. Poor outfall conditions during peak flow season of drains, when the rivers are also in high flood stage, is a significant factor that inhibits effective drainage. The other problem that is becoming increasingly severe relates to the disposal of untreated municipal and industrial effluent into the drains. This is turning out to be a serious environmental hazard and little appears to have been done so far to check this highly harmful.

Pipe Drainage Projects

A number of pipe drainage projects are in various stages of implementation in Pakistan. Four projects have been completed, while the construction of another three projects has been initiated. The completed projects include East Khairpur Tile Drainage Project, Mardan SCARP, Fourth Drainage Project, and Chashma Command Area Development Project. The performance review of these projects by Bhutta et al (1996) reports that the pipe drainage projects are generally capable of controlling water table at a depth of 1.0 to 1.5m below the natural surface. The surface and profile salinity also gradually reduces with the operation of pipe drains and cropping intensities have increased by 11% due to drainage interventions.

A more focussed review of the Fourth Drainage Project however brings out quite a few issues. This Project aimed at rehabilitating / remodelling of 197 miles of existing drains, construction of 61 miles new surface drains, and provision of tile drainage to an area of 75,000 acres. The Project was initiated during 1983-84 and had been originally scheduled for completion in a period of 6 years at a cost of Rs 1290 million. The project faced numerous problems during construction phase which led to substantial delays in project implementation. The project cost also increased to Rs 1997 million and the project was completed in 13 years; implying 50% cost over-run and above 100% increase in the Project implementation period. Subsequent operation and maintenance of the completed facilities has also given rise to many issues. These include: difficulties in transfer of management responsibilities from WAPDA to Irrigation Department, issues of O&M funding, technical inadequacies in the project design, and operational constraints. All this has resulted in sub-optimal performance of the pipe drainage network, which has reflected adversely on the perceived economic viability and sustainability of the project.

Left Bank Outfall Drainage (LBOD) Project

The project aims at integrated development of about 1.28 million acres of land in the districts of Nawabshah, Sanghar and Tharparker of Sindh Province by controlling groundwater levels and improving the collection and disposal of saline drainage effluent. It is one of the world's largest drainage projects and envisages drainage water to be disposed to the sea. The original cost of the Project was RS 8,594 Million (1984), which has been revised to 23,432 Million (1994). The project commenced in 1986 and is still under implementation. The Project components include Spinal and Outfall Drain, Scavenger Tubewells, Surface and Drainage System, Remodelling of Canals, and Chotiari reservoir.

The implementation of this mega project has been delayed, apart from substantial cost over-runs. The performance and sustainability of the Project has also remained a question mark, with particular reference to the issue of disposal of saline effluent into the sea and availability of O&M funding. There has been a general lack of consistent data that could help in evaluating the project impacts and in suitably modifying the project interventions. The need for more systematic and objective monitoring is recognized, but various conflicting interests hamper its implementation.

Fordwah Sadiqia Remaining Project Phase-I

The Project had been planned to provide surface drainage facilities to an area of 671,000 acres in Bahawalnager district by constructing 402 Km surface drains and 999 structures. The Project was commenced in December 1987 at a cost of Rs 1067 Million, which was subsequently revised to Rs 2054 millions in 1995.

Despite the lapse of over 10 years and cost over-run, the project is still incomplete and the physical progress is only 64%. The reasons for delayed implementation include: lengthy and cumbersome land acquisition procedures, stay-orders by the courts, resistance by the landholders to part with their land, political polarization, and delays on the part of the contractors. A closer look into the Project implementation and its impact brings to focus serious issues related to environmental degradation in the catchment area, as the drainage effluent stagnates within the project area due to non completion of outfall drains. In fact, some of the areas have been badly affected by waterlogging and they are in a much worse state than the `without project' condition.

FUTURE STRATEGIES AND OPTIONS

Based on the past experience and performance evaluation of the existing drainage facilities, the following strategies and options are identified for the future.

Extent and Need for Drainage

The surface and sub surface facilities so far have been completed in a gross area of 15 million acres at a cost of Rs 21 billion, while projects costing over another Rs 20 billion are in pipe line to drain additional area of 5.4 million acres (World Bank, 1996).

Since 1978, the area with a depth to water table less than 5 feet in April / June has been varying between 5 to 6 Ma (14%). Of this, 1.25 Ma are located in completed projects, 2.10 Ma in on-going projects and 2.54 Ma in the remaining area not covered under the projects. Of the area within completed SCARPs having shallow water table, 0.94 Ma lies in projects provided with tubewell drainage and needs either O&M improvements or additional measures. In rice area, improvement in surface drainage system is also indicated.

The total future drainage requirements have been estimated by NDP Consultants as 18.81 Million Acres. Table 3 provides province-wise and category-wise details of future drainage requirements (NESPAK et al, 1995).

Table 3 :Future Drainage Requirements (area in Ma)

Province	Surface			Sub-surface			Total		
	C	O	N	C	O	N	S	SS	Total
Punjab									

		1.42	1.20	0.78	0.60	3.58	2.62	4.96	7.58
Sindh	1.08	1.57	2.41	0.16	1.43	3.08	5.06	4.67	9.73
NWFP	-	-	-	-	0.39	0.31	-	0.70	0.70
Balochistan	0.07	0.50	0.23	-	-	-	0.80	-	0.80
Total	1.15	3.49	3.84	0.94	2.42	6.97	8.48	10.33	18.81

Note :- C: Completed, O: Ongoing and N: New Projects
S: Surface, SS: Sub Surface

Drainage Priorities and Technologies

The drainage problems in Pakistan relate mainly to the saline ground-water areas, as private tubewells are generally helping in drainage of FGW areas. There is an urgent need to carry out diagnostic review of the current drainage practices with a view to identify constraints in effective drainage in SGW areas and design remedial measures thereof. The previous experience appear to suggest that deep pumping in SGW areas is not very effective due to large capital costs, rapid deterioration of strainers, high operating costs, problems of effluent disposal and lack of farmers interest in tubewell operation.

There is a need to explore and adopt new technologies for cost-effective and sustainable drainage interventions. Low-cost sub-surface pipe (tile) drains and skimming of top layers of comparatively fresh ground-water lenses hold promise and need to be developed through site-specific action research. High water allowances and inefficient irrigation practices leading to excessive losses and drainage problems need careful consideration. The concept of integrated water management alongwith selective canal lining can be helpful in addressing the twin menace of water-logging and salinity. In fact, this may be a more feasible and sustainable option in most of the cases.

Biological drainage is relatively a new concept which offers considerable potential as an alternative option where drainage cost is high and disposal of saline effluent poses economic and environmental concerns. The biological treatment includes plantation of certain categories of plant species that are tolerant of the above conditions. The biological approach will make the lands productive by lowering the water table. Biological drainage is cost-effective, little O&M is involved, provide a renewable source, and is environment - friendly.

Optimization of Drainage Performance

Towards this end, the following measures are suggested :

1 Establishment of Drainage Boards.

Drainage in Pakistan is the responsibility of several Federal and Provincial units of the Government. WAPDA, which is under the Federal Ministry of Water & Power, designs and constructs open surface drains, tubewells and pipe drains in all the four provinces. The provincial governments operate and maintain the drainage system after construction. This institutional fragmentation of responsibilities for land drainage is impeding the promotion of integrated water management and can only be alleviated through effective coordination mechanisms. To start with Drainage Boards be established at Canal Command / Area Water Board levels which may include representatives of the Federal and Provincial governments and the farmers for optimizing planning, implementation and management of the drainage projects.

2 Rehabilitation of the existing Surface Drainage System.

The surface drains are the backbone of any drainage system, because they are the outlets for all the drainage effluent. In the Indus plains, low velocities and sedimentation occurs coupled with the problems of sloughing and side slope erosion. Another major problem of maintenance in open surface drains is the weed growth which increases the channel roughness and decreases the cross-sectional area. Both these factors decrease drain capacity and increases flow depth, resulting in flooding of the adjoining areas. Although many biological and chemical treatments have been suggested in the literature for control / removal of the weed growth in surface drains, yet as per local conditions, the dragline excavation appears to be the best solution. There is need to deploy excavators on the main system of surface drains, which should work continuously for efficient and timely maintenance of the surface drains.

3 Improving outfall conditions of surface drains.

It has been experienced over the decades that the outfall conditions for main and branch drains are not favourable, particularly in the provinces of the Punjab and Sindh. To avoid stagnation / spillage of water and also to have a desirable control over the water table, the pumpage at the outfall points , with unfavourable outfall conditions, is a must. Because of isolated locations of outfall points, low-cost energy pumps need to be researched / installed.

4 Groundwater Management.

The purpose of the groundwater management is to enforce the national use and the conservation of the water resources. Development of the ground water in fresh water zones be left to private sector, with only technical assistance from the public sector. In case of saline groundwater areas, no pumpage be allowed till such time that a comprehensive and environmentally sound disposal network is constructed. The experience of evaporation ponds has many negative effects on crops and livestock. The computer models available in the country can be further modified to control and monitor the water table in the irrigated areas and linked to GIS data base. Lot of initial work has been done, but more is needed for early establishment of the water balance in the Indus Basin and its sub basins. Once the water balance is available, the salt balance can then be planned and managed. A Master Plan for ground water management is essential for the sustainability of irrigated agriculture in Pakistan.

Encouraging the Use of Gypsum

The widespread use of groundwater, which invariably is of lower quality than canal water, is resulting in secondary salinization of soils with concomitant reductions in yields even when water is abundant. The problem is much more pronounced in the areas where marginal quality groundwater having high sodium content is being used. In these areas, the development of surface sodicity is compounding the problem. One IIMI field study of two distributaries in the Lower Chenab Canal system in Punjab found that, in the areas served by watercourses at the tail of the distributaries, between one-third and one-half of the fields had salinity levels high enough to reduce photosynthesis in the crops grown. Even in the areas served by middle-reach watercourses, 5 percent of the field had similarly high salinity levels (Vander Velde and Kijne, 1992).

In order to check the negative environmental impacts of secondary salinity and surface sodicity caused by the application of marginal quality groundwater, the use of gypsum needs to be encouraged. Appropriate policies should be formulated and implemented by the Government in this regard.

Financial and Economic Aspects of Drainage Projects

Three questions must be addressed when financial viability of a drainage project is considered. These include :

- Whether there will be funds to complete it?
- Whether there will be funds to maintain it effectively ? and
- Whether the economic and social benefits will make it worthwhile?.

The financial aspects of drainage projects have remained a concern in Pakistan. Inadequate funding for drainage construction has been a major constraint in timely completion of most of the projects (e.g. LBOD, FES etc) while lack of O&M funds impinge very adversely on performance of the completed facilities (e.g. LBOD, Fourth Drainage Project, Surface Drainage Schemes, Tubewells, etc). It has been estimated that the current O&M allocations for drainage projects cover only 10-15 percent of the needs (NESPAK and MMI, 1995). To provide efficient and sustainable drainage services, collection of service charges is essential to meet the growing O&M needs. The questions that arise are :

- Who should pay for drainage ?
- What percent of drainage cost is recovered ? and
- How the drainage cost is to be shared, charged and collected ?

In most of the cases, drainage problems are not the creation of local beneficiaries but a sequel of other interventions upstream or downstream. Therefore identification of beneficiaries and sharing of drainage O&M cost pose difficulties. The review of cost of drainage projects in Pakistan suggests that the investment and the operating costs are high, and not affordable by the farmers alone. Considering the state of the country's agriculture and health of rural economy, financing of even the O&M costs would be much beyond the paying capacity of the farmers. There is thus a need to carefully review this issue with a view to identify drainage options that are more economical and financially sustainable. There is also need to formulate a national policy on the recovery of drainage costs, in order to ensure that the constructed facilities do not fall into dis-repair due to lack of O&M funding.

Regarding economic aspects, it has to be appreciated that the complexities associated with drainage projects render rigorous economic treatment difficult to undertake. Delays in project completion, cost over-runs, and sub-optimal O&M can distort the economic viability of the project dramatically (e.g. Fourth Drainage, LBOD, etc). The impacts of these factors have to be clearly understood and a consistent framework needs to be evolved to optimally manage project implementation and its subsequent operation to achieve the perceived benefits.

Sustainability of Drainage Interventions

Sustainability of drainage interventions is being jeopardized because of lack of a consistent policy / planning framework, substantial delays in project completion, sub-optimal operation, and inadequate attention to the financial and environmental considerations. Heavy reliance on expensive solutions offered by the foreign consultants and the aiding agencies has been the major constraint in way of the sustainable development. In this behalf, the experience of large capacity SCARP tube-wells in public sector is relevant, which were taken up on the insistence of the foreign consultants. These projects however were not financially sustainable due to the high O&M expenditure and ultimately had to be dis-invested. Lack of an independent and objective Monitoring and Evaluation System is another serious issue that hampers policy makers capability to learn from the experience and to implement measures for course correction.

Therefore urgent action must be taken to address these constraints in an effective and efficient manner. Careful study may be conducted to devise low-cost indigenous technologies and to relate / integrate the proposed drainage interventions with the existing farming systems and financial resources of the country for achieving the objective of sustainable development.

Research and Development under Drainage Sector

For effective and economical management of the drainage interventions, the Government needs to intensify the research and development efforts, as this important aspect has received inadequate attention in the past. There is dire need to establish Drainage Research Institute at Faisalabad to plan and integrate drainage research in Punjab. The following are the main areas of research :

- Appropriate choice of irrigation and drainage technology.
- Effective operation and maintenance of drainage facilities.
- Drainage effluent disposal.
- Management of surface and groundwater.
- Minimizing sub surface drainage needs.
- Environmental protection and checking hazards of drainage projects.
- Action Research on low cost indigenous drainage measures.

High priority should also be given to the development of human resources and retaining the services of highly qualified professionals for drainage research. The future challenges of water resources management necessitates training of water management staff at all levels. Training capacities should be adequately strengthened and updated from time to time, taking into account the advances made in drainage and water resources management. The farmers and the NGOs must also be closely associated and be made the integral part of the training programs.

CONCLUSIONS AND RECOMMENDATIONS

The following major conclusions and recommendations are brought out :

The overall performance of past drainage interventions has been quite uneven and mixed. The streams of major issues and concerns are clearly distinguishable alongside the partial success stories. The brighter side of the picture includes partial control of waterlogging and salinity; reclamation of some of the affected areas; and development of conjunctive groundwater use. The major concerns on the grey side include declining performance of the drainage facilities after the cycle of initial successes and high rate of system deterioration partly due to deficiencies in planning / implementation and partly due to inadequate maintenance. The most striking issues however have been the lack of financial viability and the sustainability of the drainage projects.

The present approach and drainage interventions do not materially differ from the past policies and experiences. In fact, it appears that we are moving in a vicious circle. Implementation of most of the on-going drainage projects has been delayed while operation of the completed facilities continues to pose problems.

Based on the past experience and performance evaluation of the existing drainage facilities, the following strategies and options are identified for the future.

- The extent and need for drainage should be carefully assessed.

- The drainage problems relate mainly to the saline groundwater areas, as private tubewells are generally helping in effective drainage of FGW areas.

- There is an urgent need to carry out diagnostic review of the current drainage practices in order to identify drainage constraints in SGW areas and plan effective remedial measures.

- There is a need to explore and adopt new technologies for cost effective and sustainable drainage interventions. Low-cost tile drains, shallow skimming wells, selective lining, integrated water management and biological drainage appear to hold promise.

- Effective surface drainage can be quite helpful in evacuation of excess water and in controlling the water table depth. Measures for improved O&M of surface drains are therefore indicated.

- Establishment of Drainage Boards, rehabilitation of the existing surface drainage systems, improving the outfall conditions of the existing drains, and measures for groundwater management are suggested for optimizing the performance of the drainage facilities.

- In order to check the negative environmental impacts of secondary salinity and surface sodicity caused by the application of marginal quality groundwater, the use of gypsum needs to be encouraged. Appropriate policies should be formulated and implemented by the Government in this regard.

o The financial aspects of drainage projects have remained a concern in Pakistan. A review of cost of the drainage projects suggests that the investment and operating costs are high, and not affordable by the farmers alone. Need to formulate a national policy on the recovery of drainage costs is indicated in order to ensure that the constructed facilities do not fall into disrepair due to lack of O&M funding.

o Sustainability of the drainage interventions should be the prime focus and centerpiece of all the policies and strategies. The future drainage interventions should be designed to achieve the goal of sustainable development. Optimal use of indigenous technologies and reliance on local resources supported by a well-designed program of research and development can be instrumental in realizing this objective.

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