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SINDH WATER RESOURCES MANAGEMENT – ISSUES AND OPTIONS

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FAO/WORLD BANK COOPERATIVE PROGRAMME

PAKISTAN

SINDH WATER RESOURCES MANAGEMENT
ISSUES AND OPTIONS

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CURRENCY EQUIVALENTS

Currency Unit = Pakistani Rupee (Rs)
US$1.0 = Rs 60.55

FISCAL YEAR

July 1 -June 30

MEASURES AND EQUIVALENTS

1 meter	=	3.28 feet
1 ha	=	2.47 acres
1 km	=	0.620 miles
1 cubic meter (m^3)	=	35.310 cubic feet
1 million acre foot (MAF)	=	1.234 Billion cubic meter (Bm^3)
1 cubic feet per second (cusec)	=	28.5 litre per second (l/s)
		0.0285 cubic meter per second (m^3/s)

ABBREVIATIONS AND ACRONYMS

Abiana	Water Charge
AWB	Area Water Board
Bm^3	Billion cubic meter
CCA	Cultivable Command Area
EPA	Environmental Protection Agency
ERR	Economic Rate of Return
FAO	Food and Agriculture Organization
FGW	Fresh Groundwater
FO	Farmer Organization
GOP	Government of Pakistan
IBIS	Indus Basin Irrigation System
IPTRID	International Programme for Technology and Research in Irrigation and Drainage
IWASRI	International Waterlogging and Salinity Research Institute
LBOD	Left Bank Outfall Drain
M&E	Monitoring and Evaluation
MW&P	Ministry of Water and Power
NDP	National Drainage Project
NGO	Non-Government Organization
NWP	National Water Policy
O&M	Operations and Maintenance

OFWM	On-Farm Water Management
PID	Provincial Irrigation Department
PIDA	Provincial Irrigation and Drainage Authority
RBOD	Right Bank Outfall Drain
SCARP	Salinity Control and Reclamation Project
SIDA	Sindh Irrigation and Drainage Authority
TA	Technical Assistance
TYYDP	Ten Year Perspective Development Plan
WAPDA	Water and Power Development Authority
WCA	Watercourse Association
WUA	Water User Association

FOREWORD

In 2000, the Federal Government of Pakistan transferred the responsibility for management and development of water resources to its Provincial Governments. Irrigated agriculture is important in poverty alleviation in Sindh Province, where this study was undertaken on behalf of the Government of Sindh and the World Bank. This paper presents issues and options for water resources management, in particular in the irrigation and drainage sub-sector. The paper outlines operations and maintenance; service delivery; on-farm productivity; asset management and, most importantly, modernization in place of rehabilitation of irrigation and drainage infrastructure, as rehabilitation has been found to perpetuate the vicious cycle of "building, neglecting and rebuilding". This paper is leading to the preparation of the Sindh Water Sector Improvement Project, under proposal for financing by the World Bank. The preparation of the paper was by the FAO Investment Centre. The study is relevant to other countries interested to improve management of their water resources.

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PAKISTAN

SINDH WATER RESOURCES MANAGEMENT – ISSUES AND OPTIONS

A. INTRODUCTION

1. The water sector is expected to fulfil social, environmental and economic needs. In a context of growing water scarcity exacerbated by rapid population growth and urbanization, misallocation of resources, environmental degradation such as seawater intrusion, and mismanagement of water resources, the Sindh province faces new challenges, which call for a new approach to water resources management. Water is a single resource with many competing uses. Experience has adequately demonstrated that water management is complex and multi-level and requires a comprehensive framework. A sectoral or sub-sectoral approach needs therefore to be replaced by an integrated approach, which takes account of social, economic, and environmental objectives, assesses water resources, evaluates and manages water demand, and seeks stakeholders' participation. A long-term vision is required to set the tone and provide the guidance for Sindh's on-going water sector reforms.

2. This paper reviews the objectives and roles of federal and provincial government and non-Government entities in management of water in Pakistan, particularly in Sindh, the contribution of the sector to agriculture and rural development, identifies issues and options with particular focus on integrated water resource management and poverty alleviation. The paper would form the basis for discussions among the stakeholders for the development of *Sindh Water Vision 2025*.

3. The paper is based on a desk study undertaken by the FAO/World Bank Co-operative Programme (FAO/CP[1]) based on published information available as detailed in the bibliography. Subsequently a series of consultations were undertaken in July 2003 with officials from: (a) relevant provincial departments and local development research organizations and NGOs in Karachi; (b) federal institutions and international organizations in Islamabad (c) the Water and Power Development Authority and Consultants for the National Drainage Programme in Lahore and (d) the Sindh Irrigation and Drainage Authority in Hyderabad.

B. OBJECTIVES OF THE WATER RESOURCE SECTOR

Overall Water Polices

4. The federal government plays an important role in establishing the overall framework and guidelines for the provincial-level operation in the sector, and has made attempts at promoting better water allocation, planning and management. The most recent comprehensive statements on water are:

[1] A. Azad, Land and Water Development Engineer, FAO Investment Centre; M. Aslam Rasheed, Senior Water Resources Engineer (FAO National Consultant); and Yameen Memon, Senior Agricultural Economist (FAO National Consultant).

- National Water Policy (Ministry of Water and Power, 2003);
- Water Sector Strategy (Ministry of Water and Power, 2002);
- Vision 2025 (Water and Power Development Authority, 2001); and
- National Drainage Strategy and Drainage Master Plan (Under preparation).

5. The national water sector strategy (see Attachment 1 for the summary and framework of the national water sector strategy) has adopted, as its primary objective, the Vision Statement of the National Water Policy (NWP) which is: *"By 2025, Pakistan should have adequate water available, through proper conservation and development. Water supplies should be of good quality, equitably distributed and meet the needs of all users through an efficient management, institutional and legal system that would ensure the sustainable utilization of the water resources and support economic and social development with due consideration to the environment, quality of life, economic value of resources, ability to pay and participation of all stakeholders."*

6. The primary concern over the NWP and other policy statements, however, is that they have not been translated into action. They are not supported either by institutional structures and mechanism, enabling legislation, or by supporting economic incentives. A secondary concern is that while the NWP and other policy statements are broadly in the right direction, they would require periodic review and updating to bring them in line with the current status of water resources management and the further evolution of the water sector thinking in Pakistan and internationally. There are also a number of issues, which are not touched by the policy statements. These include:

- inter-sectoral and inter-provincial conflicts for water use - the extent to which these exist, their context, and the machinery for resolving them;
- the quality of hydrological information and the extent to which it might need to be upgraded for conflict resolution purposes; and
- environmental, social and poverty issues while there are references to pollution problems, there is little reference to how these should be dealt with; nor is there any discussion on poverty and social effects of the drainage effluent, environmental flows and the sea water intrusion.

Changing Responsibilities in the Water Sector

7. Responsibility for the water sector is shared between federal and provincial bodies. Policies and planning are the responsibility of the Federal Ministry of Water and Power (MW&P) and the federal Planning division; the large inter-provincial dams are under the control of Water and Power Development Authority (WAPDA); and irrigation and drainage up to the field canal intake is managed by the Provincial Irrigation Departments (PID) and Provincial Irrigation and Drainage Authorities, whereas watercourses and other on farm activities fall in the purview of the Provincial Agriculture Departments.

8. While there are several federal agencies with responsibility for various areas or sub-sectors of water, there is no appropriate inter-provincial body to oversee integrated water sector planning, development and management. Such a body is needed to oversee the implementation of the water sector strategy and to ensure that investments are targeted specifically at achieving its

objectives. It is also needed to broker a consensus on the major initiatives of the Water Strategy, which are inter-ministerial and/or inter-provincial in nature, such as addressing environmental problems; sea water intrusion, drainage, water conservation, improvements in agricultural yield and production, and the development of additional water storage etc.

9. The waters of the Indus River basin are allocated to the provinces through the Water Accord, which is implemented by the Indus River Systems Authority (IRSA). A National Drainage Master Plan, which is likely to form the basis of a Drainage Accord is under preparation. There are frequent disputes over water allocation, especially in sharing water during dry periods. This has led to controversy between the provinces which has contributed to the slow growth is water resources management in the past decades.

10. The Devolution Plan of August 2001 decentralises most public sector activities from the federal and provincial levels to the district level, including public sector water supply and sanitation and On Farm works. The former provincial Public Health Engineering Departments and the On farm Water Management Directorates have been reduced or even dissolved. There is some concern that the district authorities will lack the technical and managerial skills needed to support development of rural water supply and sanitation as well as water management. It is hoped that these problems will be worked out as the district administrations comes to grips with their new responsibilities. The effectiveness of the districts in planning and development of rural water supply and sanitation and watercourse improvement should be monitored to ensure that these remain on track and that assistance is provided where needed.

11. Existing user level organizations include: NGOs; Watercourse Associations (WCAs) at the watercourse level; Farmer Organizations (FOs) at distributary/minor canal level; Drainage Beneficiary Groups (DBGs); Community Tubewell Organizations (CTWGs) and Rural Village Water and Sanitation Groups.

Sindh Irrigation and Drainage Authority (SIDA)

12. Recognizing the need for a new strategy to solve the irrigation and drainage problems, the Government of Pakistan, in 1995, adopted a new program to establish a self-sustaining irrigation and drainage system. This involves (a) transforming Provincial Irrigation Departments into Provincial Irrigation and Drainage Authorities (PIDAs); (b) creating Area Water Boards (AWBs); and (c) organizing farmers into Farmer Organizations (FOs). Under such reforms, all provinces established irrigation and drainage authorities through Acts passed by the assemblies in their respective provinces. This was in fact a first major move to introduce participatory irrigation management through out the country. Out of the four Provinces in Pakistan the reforms have been significant in Sindh at all levels.

13. The Sindh Assembly passed the SIDA Act in 1997. As a result of the Act, the Sindh Irrigation and Drainage Authority (SIDA) was established in 1998 followed by one Area Water Board (AWB) on the Nara Canal in 1999. Since then AWBs have been established in Ghotki Feeder and Fuleli/Akram Wah canals. The respective AWBs are responsible for operation and management of these 3 canals where farmers' are represented on the Boards.

14. Farmer Organizations (FOs) are being established at distributary/minor canals level to take over responsibility of O&M and collecting water charges under formal irrigation and

drainage management transfer (IDMT) agreements. Ultimately over 1200 FOs are to be established in the 14 canal commands/AWBs of Sindh to manage O&M and collect water charges. By end of June 2003, some 192 FOs (162 of these in Nara Canal AWB) have been established, and formal IDMT Agreements have been concluded with 82 FOs. On July 24,2003 IDMT Agreements have been concluded with 30 more FOs, which increases the number of FOs to whom management has been transferred to 112.

15. Some of the main functions of SIDA are:

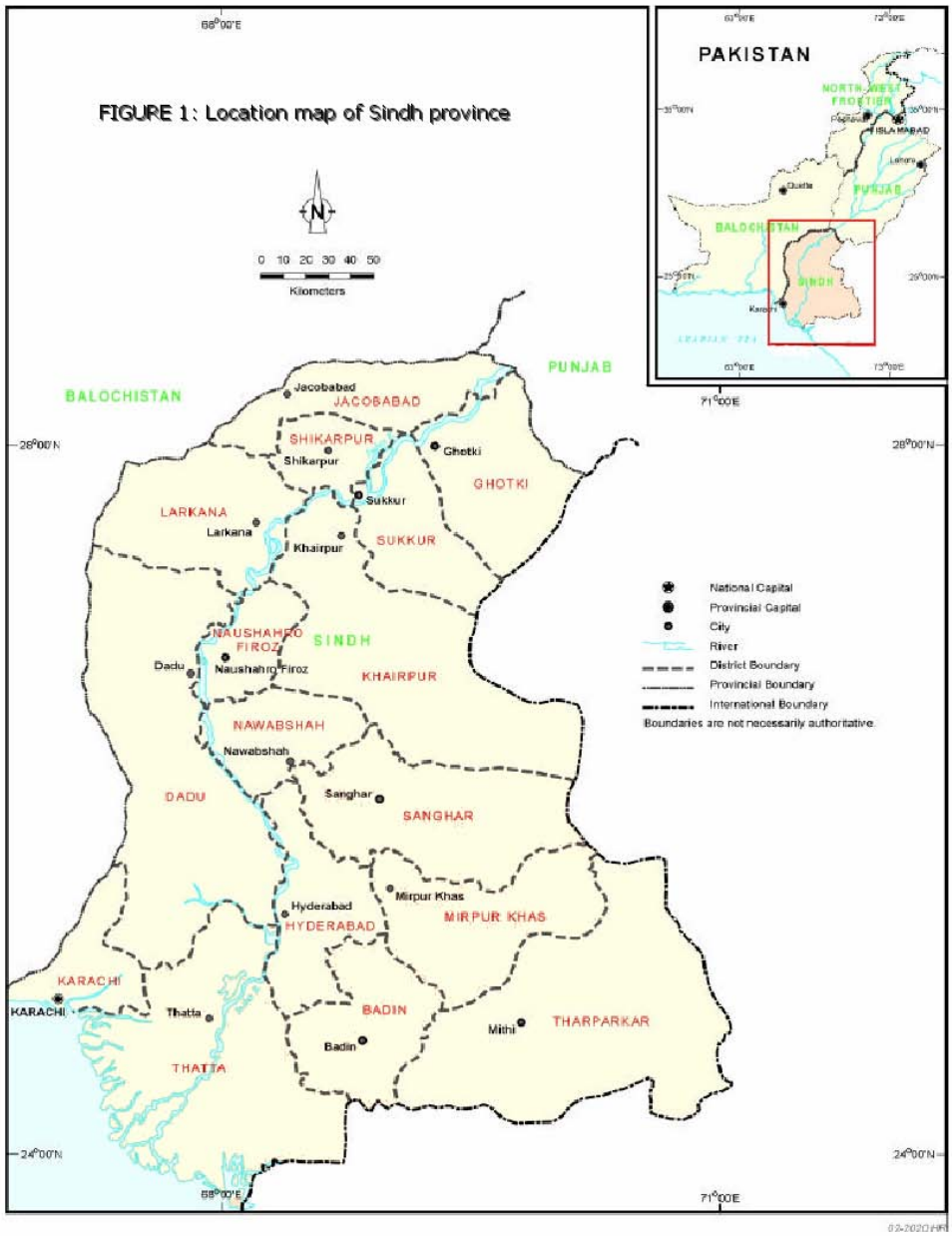
- to receive irrigation supplies at the barrages within the Province and from inter-provincial and link canals, and deliver in agreed amount to the AWBs;
- manage the drainage effluent in their province;
- fix and levy the water charges and drainage cess;
- plan, design and construct the irrigation and drainage infrastructure (irrigation tube wells, drainage, storage reservoirs and flood control infrastructure);
- operate and maintain irrigation and drainage infrastructure organization; and
- control and manage groundwater resources.

16. In January 1998, the Government of Pakistan (GOP) launched the National Drainage Programme Project (NDP), which aimed at a revival of an environmentally sound irrigated agriculture in the Indus Basin through a mix of social and engineering solutions.

17. The SIDA Act did not fully represent the spirit of the reforms and ensured a perpetual dominance of the irrigation bureaucracy on the new entities. This led to a massive introspection of the SIDA Act and culminated in promulgation of the Sindh Water Management Ordinance 2002. This Ordinance in principle sets the stage for a complete rollout of the reform programme. One key success factor has been establishment of a core reform team with a non-irrigation background. The key elements in the proposed reform are the transformation of the Irrigation and Power Department (IPD) into an autonomous SIDA, the arrangement of responsibilities on the basis of hydraulic units (canal commands), self-financing of irrigation and drainage services over 7-10 years and decentralization of O&M responsibilities to Farmer Organizations.

C. WATER RESOURCES CONTRIBUTIONS TO AGRICULTURAL AND RURAL DEVELOPMENT

18. Sindh is the second largest province of Pakistan according to population. It is bounded on the North by the Punjab province, on the West by the Balochistan province, on the East by India and on the South by the Arabian Sea (See location Map Figure 1). The province covers an area of 140,900 km^2- 17.7% of the total area of Pakistan and has a population of about 33 million, 23 % of total population of Pakistan.



19. Poverty has been increasing in Pakistan since the 1990s, after declining during the previous two decades. In particular women suffer disproportionally from poverty. Data indicate that the poorer the household, the higher the likelihood of dependence on female labour. Women's access to the formal labour market is only 13.7% and women have relatively lower skills and literacy base, concentrating their work in low-paid or undervalued employment sectors. Poverty levels are high in Sindh: 37% of the population live below the poverty line; 20% of the urban and 53% of the rural population are poor which consists of the over half of the households that do not own agricultural land, and the further one quarter of households that own 2 hectares (ha) or less. While economic growth in the farm and non-farm sectors is a necessary condition for improving rural livelihoods, this growth must have a core pro-poor dimension if it is to generate significant improvements in the livelihoods of the agricultural communities in rural Sindh. Imbalance in

access to resources and the use of new technologies, weak governance, and a lack of empowerment constrain any benefits from "trickling down" to the poor.

20. Agriculture is the main stay of Pakistan economy. . The agricultural sector, with a share of about 25 percent, was the single largest contributor to the GNP. . About 68% of the rural population depends on agriculture, which employs over 46 percent of the labour force and accounts for more than 60 percent of foreign exchange earnings. Pakistan's economic development is therefore directly linked to the progress of the agriculture sector. Sindh's contribution to Pakistan's agriculture GDP is 23% with its contribution of major products as follows:

- Wheat 15%
- Cotton 23%
- Livestock 28%
- Sugarcane 31%
- Rice 42%
- Marine fish 70%

21. Agricultural progress of Sindh province is linked with the supply of irrigation water from the river Indus. Wheat, cotton, rice and sugarcane are the major field crops, which constitute 68% of the total cropped area, while mango, banana and chillies are the major horticultural crops. Crop yields compared to Punjab are generally low which have remained either stagnant or increased at slow rates. Availability of quality seed of desired crop varieties continues to be a problem of major concern for Sindh agriculture. Use of crop inputs such as fertilizer, pesticides etc. has increased considerably without any corresponding increase in yield levels. Supply of sub-standard and adulterated pesticides and fertilizers is also affecting the crop yields and the cost of production. There is increasing degradation of the resource base and current farming practices do not adequately address the issue of sustainability of crop production systems. This is besides the high cost of inputs and non-secure market prices as the main hurdles in the development of agriculture.

22. There are two growing seasons: the summer Kharif season (April to September) and the winter Rabi season (October to March). Annual cropping intensities vary significantly across canal commands. The average annual intensity in the province is about 67%.

23. **Land Tenure Arrangements**. The land tenure system in Sindh has regulated ownership, tenancy and inheritance rights. Recognizing the need for more equitable distribution of agricultural land and security of tenancy, the GOP has attempted land reforms, with varying degrees of success. About 50% of the farms, representing about 59% of the total farm area, are operated by owners, while 42% of the farms (representing 12% of the total farm area) are operated by tenants/sharecroppers. The remaining 8% of the farms, representing 12% of total farm area, are operated by owners-cum-tenants.

24. **Land Holdings**. A majority of rural households do not own agricultural or homestead land. Of those who do own land in rural areas, fewer than 20% are large landlords but this group owns over 60% of the private farms. The existing sharecropping tenancy system, concentrated in the canal-irrigated areas, is historically deep-rooted and perpetuates the deeply entrenched poverty

of tenants and agricultural labour through unbalanced revenue-sharing and cost-sharing arrangements and a complex system of dependencies.

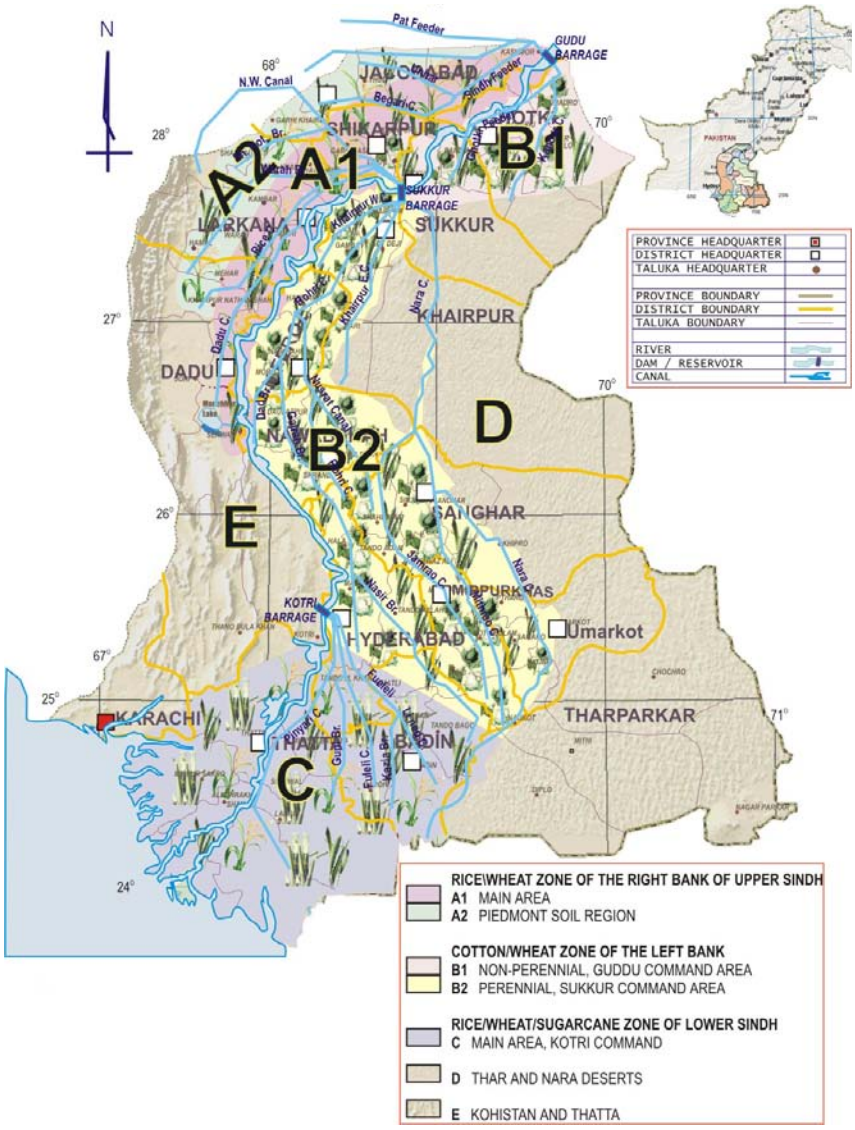
25. While the average farm size is small (4.3 ha), land ownership is in favor of large holders. There are over 800,000 farms with a total area of about 3.5 million ha. Over 93% of the farms are small (less than 7 ha) and represent 64% of the total farm area. Large farms (greater than 7 ha) are only 7% in number but represent nearly 36% of the total farm area. However, natural succession has resulted in some division and fragmentation of land. The large holdings are unproductive as considerable land is left fallow, particularly in the case of absentee land lords

26. Sindh province has been divided into three major agro-ecological zones, two of which are divided in to sub-zones, as given below.

Zone-A: - Sub-Zone A1 - Sub-Zone A2	Rice/Wheat zone of the Right Bank of river Indus (upper Sindh). Main area Piedmont soil region
Zone-B: - Sub-Zone B1 - Sub-Zone B2	Cotton/Wheat zone of the left bank of river Indus. Guddu Barrage command area Sukkur Barrage command area
Zone-C:	Rice/Wheat/Sugarcane zone of lower Sindh.

27. In addition to the above three agricultural zones, there are two more zones in Sindh (Figure 2). Zone D is a desert area in the east of Sindh, and Zone E is the western hilly zone.

Figure 2: Agro-ecological Zones of the Sindh Province



28. Total water use in 2002 was estimated at 57 Bm³ (46.2 MAF), of which 96.8% for agricultural purposes (1.6% is for domestic use and another 1.6% for industrial use). Groundwater abstraction for agriculture has been roughly estimated at 6.2 Bm³/year (5 MAF/year). However, in some areas, development appears to have reached the point where groundwater is saline or being mined. Some urban and rural water for household use is supplied from groundwater, whereas the major share of municipal supplies comes from the Indus. Over 50% of the village water supply is obtained through hand pumps installed by private households. In saline groundwater areas, irrigation canals are the main source of domestic water.

Irrigation and Drainage Assets in Sindh

29. The water management areas i.e. the cultivable command area (CCA) is of the order of 5.1 million ha. About 1.3 million ha is classified as cultivable waste, which could be brought under cultivation if irrigation water were available. The actually irrigated area varies from year to year depending on availability of canal water with an average of 3.785 million ha. The irrigation system below the barrages comprises 14 feeders and main canals and 1,462 branch canals, distributaries and minors (Figure 3). The following table reflects the density of canal systems. More than 95% of the irrigation is from canal water. In addition to canal irrigation some area is irrigated by other sources i.e. wells, tubewells and a combination of canals and tubewells.

Canal Type	Length km	Density m/ha
I-Irrigation canals		
Main canals	2,513	0.5
Branch and sub branch canals	4,450	0.9
Distributaries	4,276	0.8
Minor canals	6,323	1.2
Water courses (no. 43,000)	12,900	2.5
II- Drainage canals		
(a) Surface drains	5,980	1.2
Main Drains	n.av.	
Minor drains	n.av.	
Escape Drains	n.av.	
(b) Subsurface drainage		
Number of Tubewells		4,902
Area covered by tile drains (ha)		18,225
Intercepting drains in km		561

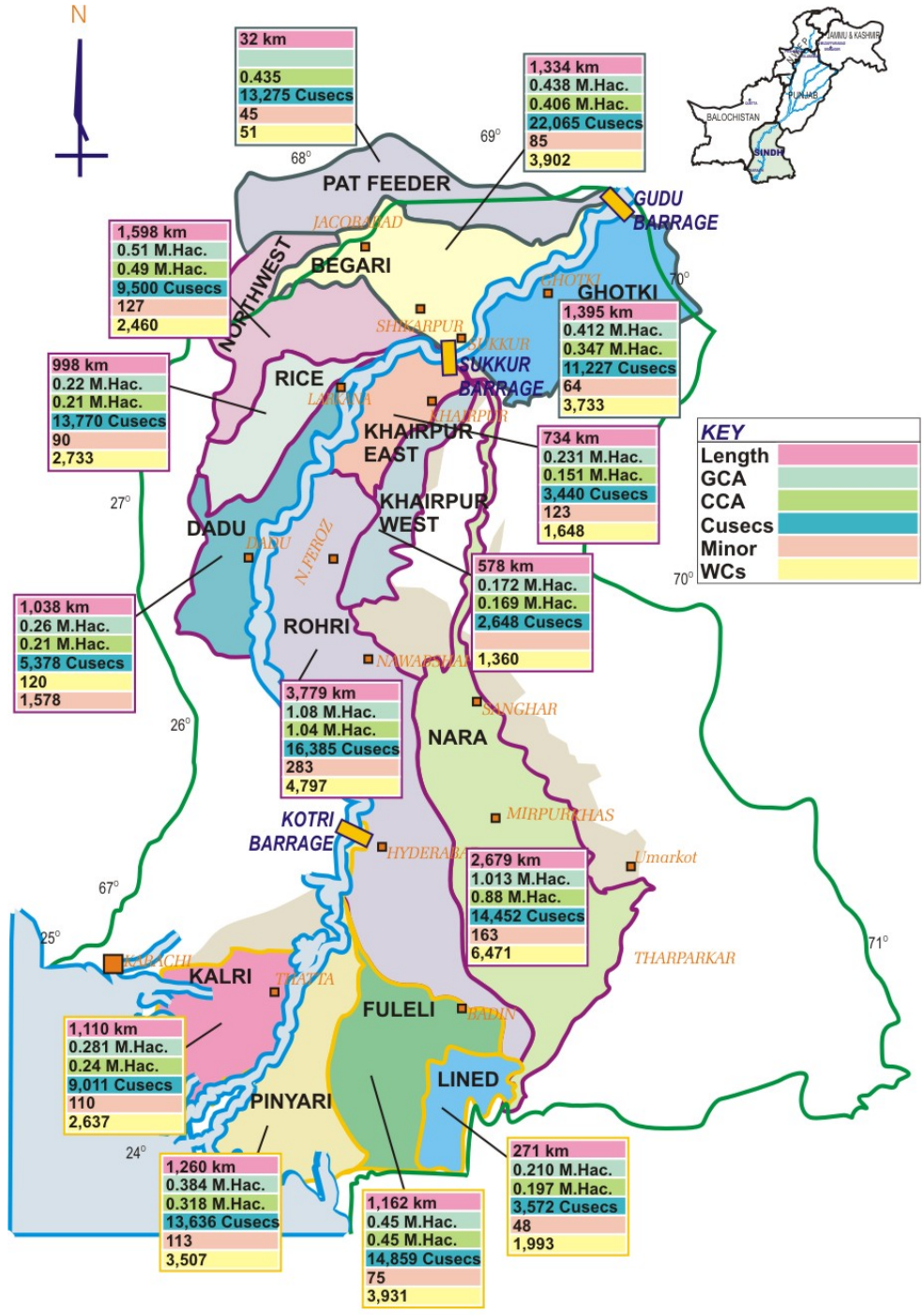
Command area: 5.1 million hectares

30. Guddu Barrage, the uppermost barrage in Sindh was commissioned in 1962 and commands an area of 0.88 million hectares through two canals on the right bank i.e. Desert Pat Feeder and Begari Sindh Feeder, and one, Ghotki Feeder on the left bank. The diversion capacity of the canals off-taking from Guddu Barrage is 1,281 m^3/s (45, 232 cusecs). The present discharges carried by the system are 24% higher than designed. The Desert Pat Feeder also carries the share of the Pat Feeder canal in Balochistan province.

31. Sukkur Barrage commissioned in 1932 commands one of the largest irrigation networks in the world. It commands an area of about 3 million hectares through North Western, Rice and Dadu Canals on the right bank and Nara, Rohri, Khairpur Feeder East and Khairpur Feeder West on the left bank with a combined diversion capacity of 1,642 m^3/s(57,978 cusecs). Currently the Sukkur Barrage system is operating at 22% higher discharge than designed.

32. Kotri Barrage commissioned in 1955 commands an area of 1.17 million hectares and withdraws 991.5 m^3/s (35,000 cusecs) of water. Kotri Barrage irrigates through Fuleli, Pinyari and Akram Wah on the left bank and connects to Kalri Lake through Kalri Baghar Feeder for providing drinking water for Karachi.

Figure 3. Irrigation System of the Lower Indus Basin- Sindh Province

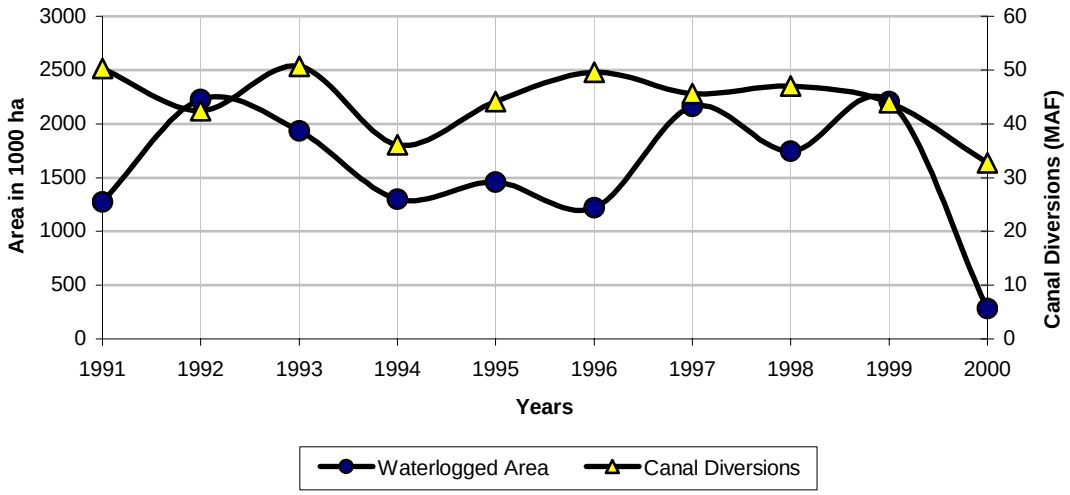


33. By design, the number of control structures in a canal was kept to a minimum; cross regulators were installed only where necessary to control operating water levels for the head works of "offtaking" channels. In Sindh, the distance between regulators on main canals averages about 24 kilometres, about 16 kilometres on branch canals, and 32 km on distributaries. The lowest point in the system for regulation is at the headworks of distributaries, which very often carry 6-9 m^3/s(about 200 to 325 cusecs).

34. Almost 50% of the CCA amounting to 2.4 million hectares does not have drainage facilities. The present surface drainage density (see also the above table) is usually not more than 3-7 m /ha which leaves much of the land (including most minor depressions) without a nearby outfall.

Waterlogging and Salinity

35. Sindh has serious problems of water logging and salinity due to the nominal gradient, accretion of riverbeds, inadequate salt exit and traditional watering of crops. The problems of water logging and salinity pose a major threat to sustainability of irrigated agriculture on about 30 percent of irrigated lands in Sindh. This situation is aggravated by the low efficiency of the irrigation system. Extraction of deep groundwater further aggravates the issue. In 1999, the waterlogged area, with water table depth 0 to 1.6 metres, was 2.2 million ha, which however drastically reduced to 285,000 ha due to drought conditions in 1999-2000, but would be likely to increase again once the canal supplies return to normal as is indicated by the past trend shown below.



36. Sindh manages its saline effluent through Kotri, Sukkur and Guddu barrages commands by treating the entire left bank area, below Guddu up to the sea, independently of the right side of the Indus river. The effluent of five canal commands in a row encompassing about 3 million hectares on the left side is, to some extent, drained through the Left Bank Outfall Drain (LBOD). The whole area is covered by five completed salinity control projects while another six of them are at different phases of planning and execution. This besides the Kotri command's four canal systems, which are drained directly to the Arabian Sea through a network of 12 drains of which three discharge into the Indus River.

37. Soil salinity in Sindh has been increasing with the expansion of irrigated area. In shallow ground water (SGW) areas salinity remains at a very high level of 3,900 – 4,000 ppm while in fresh ground water (FGW) areas, salinity is estimated to have increased from 900 ppm in 1988 to 940 ppm in 1995. The extent of saline area in Sindh is shown in following table.

Irrigated Areas Affected by Salinisation

	Area (million ha)
Cultivated Land	
Non-saline land	3.67
Slightly saline land	0.33
Saline sodic and saline Gypsiferous land	0.12
Saline sodic land	0.10
Sub-total:	**4.12**
Uncultivated Land	
Saline with sparse vegetation	0.86
Saline – barrend	0.11
Sub-total:	**0.97**
Total Command Area:	**5.1**

38. As seen from the above data, nearly 16% of the cultivated land is affected by salinity, whereas the entire uncultivated land is saline. Out of the total CCA of 5.1 Mha, 1.62 Mha (About 32%) is saline and nearly 43% is waterlogged. Control of water logging and reclamation of saline lands will substantially increase the crop yields and crop production and as such should continue to receive priority in investment in the water sector.

Flood Control

39. Pakistan has had a long history of repeated localised and widespread flooding that has caused loss of life, substantial damage to property and infrastructure and loss of agricultural crops and land. Both banks of the Indus River in Sindh are vulnerable to damage caused by floods as it flows centrally through the province and have been provided with flood protection embankments. In addition, a bund along the western periphery of the Sukkur Barrage Right Bank Canal Command area known as the Flood Protection Bund has been constructed to protect the irrigated area from torrential discharges from Khirthar Hills Range and Balochistan. The 2,135 km length of flood protective embankments is distributed in 1,389 km of front line embankments, 493.6 km of loop embankments and 253.3 km of flood protective embankments. The flood protection infrastructure is generally not maintained but repaired after damage caused by floods.

40. The Federal Flood Commission (FFC) was created in 1977 following the very severe flooding in 1973 and 1976 to coordinate the flood protection activities all over Pakistan. It undertook the preparation of the National Flood Protection Plan in 1978. Phase I under this Plan, was implemented during the period 1978-88. During this period 350 flood protection schemes were implemented all over Pakistan at a cost of Rs 1.73 billion. The National Flood Protection Plan was revised to cover the period from 1988 to 1998 and the National Flood Protection Plan-II (NFPP-II) was implemented during the period 1988-98 wherein 170 schemes were completed at a cost of Rs 2.542 billion. During the same period several foreign funded projects, both for flood damage restoration and flood protection were also implemented.

41. The First Flood Protection Sector Project (FPSP-I) was implemented between April 1989 and December 1997 with the financial assistance of the Asian Development Bank at a cost of Rs 4.8 billion. Flood Protection Sector Project-II (FPSP-II) commenced in April 2000 but has encountered major delays. The project has been reformulated and the total cost is now reduced from Rs. 8 billion to Rs. 4.342 billion, however even the reformulated project has not recommenced.

Operation and Maintenance (O&M)

42. Allocations for O&M by the provincial government are generally made on an l arbitrary basis keeping in mind historical trends without regard to field conditions or costs. The actual allocations depend upon the availability of funds and seldom match the requirements.

43. The O&M expenditure of the PID in 2002 amounted to Rs 4,420 million (US$76.2 million). Establishment costs amounted to almost 50% of the total budget, followed by expenditure on electricity, tubewells and lift pumps, which consumed 35% of the budget. The expenditure on the maintenance of canals and embankments amounted only 15% of the total expenditure. The surface drainage systems are the most neglected part of the infrastructure. These are followed by the flood protection infrastructure, which is generally not maintained but repaired after damage caused by floods.

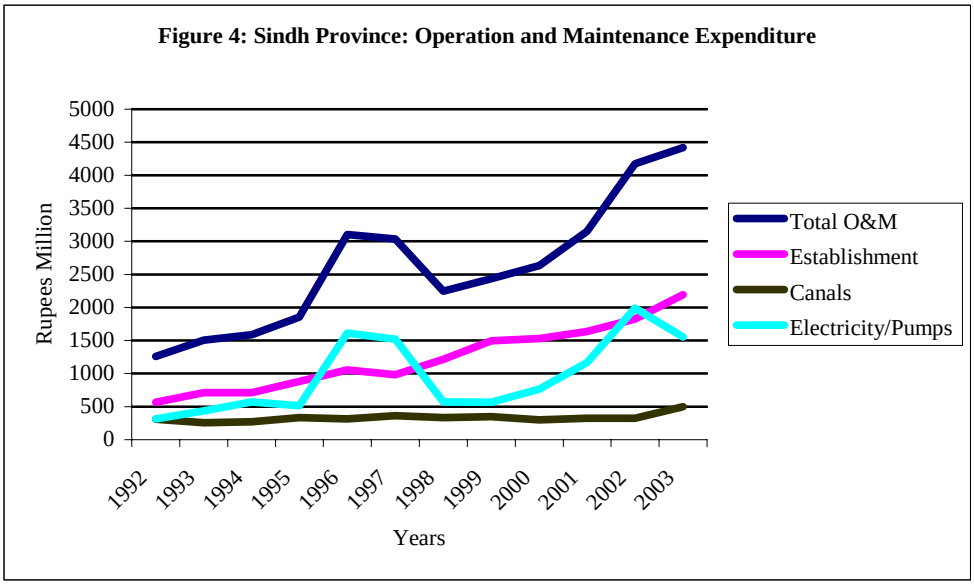
44. The following table and Figure 4 shows a category wise break up of the annual O&M expenditure of the PID.

Operation and Maintenance Expenditure
Rs million

Year	Administration	Canals	Tubewells, Pumps and Drains/ Electricity	Dams (embankment Works)	Total
1992	568	312	313	67	1260
!993	712	257	435	98	1503
1994	713	269	569	39	1590
1995	882	332	512	127	1854
1996	1053	313	1610	127	3103
1997	982	362	1518	171	3033
1998	1215	336	570	123	2244
1999	1497	347	564	27	2435
2000	1530	300	766	36	2632
2001	1637	326	1167	21	3151
2002	1826	326	1991	30	4173
2003	2194	498	1553	175	4420

Source: Irrigation and Power Department.

Figure 4: Sindh Province: Operation and Maintenance Expenditure



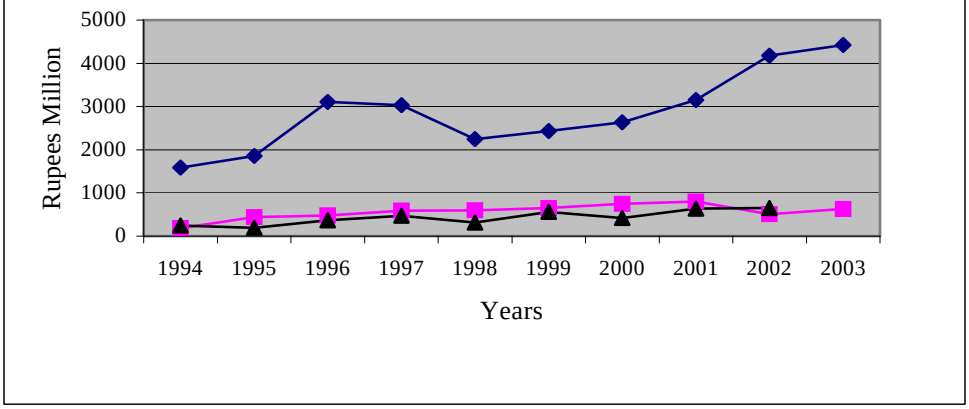
45. Over the years, the same trend is observed and administrative costs averaged almost half the budget every year. Budget allocations for tubewells, pumps and drains had the second largest share followed by allocations for canals. The reduction in the cost of 'tube-wells' in the last few years is mainly due to the fact that a large number of such tubewells are now non-functional and some have been transferred to farmers.

46. **Cost Recovery**. Water charges assessments are based on cropping pattern and are charged per hectare basis. The recovery during 1993 and 2001 were more than the assessments. Most likely this occurred due to collection of arrears. The data on assessment and recovery of the water charges (abiana) and the degree of subsidies of O&M costs are as set out in the following table and Figure 6.

O&M Expenditures and Recovery - Rs million

Year	Total O&M Cost	Assessment of Abiana (water charge)	Recovery of Abiana	Total O&M Subsidy	O&M Subsidy Rs/ha of CCA
1993-94	1590	188	247	1402	275
1994-95	1854	445	194	1409	276
1995-96	3103	480	368	2623	514
1996-97	3033	591	472	2442	479
1997/98	2244	597	517	1647	323
1998/99	2435	649	558	1786	350
1999/00	2632	746	421	1886	370
2000/01	3151	801	633	2350	461
2001/02	4173	508	650	3665	719
2002/03	4420	627	NA	3793	744

Figure 5: O&M expenditure, water charge assessment and recovery



Water Resources Planning and Management

47. In September 2001, the Government approved a national Ten Year Perspective Development Plan (TYPDP) for the period 2001 to 2011. The TYPDP lays emphasis on overcoming scarcity of water through augmentation and conservation and restoring productivity of agricultural land through control of water logging, salinity and floods. The TYPDP envisages a reduction in incidence of poverty from the current 30% to15%. The TYPDP puts special emphasis on water resources development. The objectives of water sector development include:

- overcoming scarcity of water through augmentation and conservation;
- restoring productivity of agricultural land through control of water logging, salinity and floods;
- managing quantity and quality of drainage effluent in an environmentally safe manner;
- groundwater management through transfer of tube well to farmers, aquifer monitoring and management;
- implementing an integrated flood control and management program;
- promoting beneficiary participation in development initiatives; and
- enhancing performance of water sector institutions and implementing an effective O&M mechanism through institutional reforms, private sector participation and capacity building.

48. The main objectives in the agriculture sector are:

- to achieve self-reliance in agricultural commodities and provide food security;
- to provide export orientation by promoting the production of high value crops, fruits and vegetables;
- to promote import substitution by increasing the production of tea, milk and dairy products; and
- to improve productivity of crops, livestock, and fisheries.

49. The major new projects in the water sector proposed for implementation in the first part of TYPDP in Sindh include completion of the Left Bank Outfall Drain, and new projects for the Right Bank Outfall Drain (RBODII) and Rainee Canal. The major projects proposed for implementation beyond 2005 include the Sehwan Barrage, Inter Provincial Spinal Drain, Small Dams in Barani Areas and Flood Protection Sector Project III. Other small projects for Sindh included in TYPDP are Gaj Dam, Mol Dam and Hamal Lake Project.

50. As seen from the following table, the total cost of new projects for Sindh included in TYPDP is Rs 164.1 billion (US$ 2.73 billion).

Ten Year Perspective Development Plan

Project	Total Cost Rs billion	Starting Year	Provision in TYPDP Rs billion
Ongoing national Projects			
Left Bank Outfall Drain I	25.3	On-going	2.9
National Drainage Programme	31.4	On-going	12
New Projects in Sindh			
Right Bank Outfall Drain II	14	2001	2.9
Rainee Canal	30	2002	30
Sehwan Barrage Complex	113	2006	41
Gaj Dam	4	2006	4
Hamal Lake Project	1	2006	1.2
Mol Dam	1.9	2007	1.9
Total new projects for Sindh	**164.1**		**81**
Inter provincial projects			
Inter Provincial Spinal Drain	30	2006	14
Small Drainage Schemes	10	2006	10
Flood Protection Sector Project III	10	2006	10
Total inter-provincial projects	**50**		**34**

51. In addition to TYPDP, the Pakistan Government through WAPDA has launched a comprehensive integrated water resource and hydropower development Mega-plan, 'Vision-2025' for development of 79 Bm^3 (64 MAF) storage capacity and 27,000 MW of additional power generation capacity from hydropower and coal. Vision 2025 envisages an investment of about US$50 billion in the water and power development by 2025.

52. The Ministry of Water and Power, Government of Pakistan, through the office of the Chief Engineering Adviser/ Chairman Federal Flood Commission has prepared a Medium Term Investment Plan (MTIP) for the Water Sector under the Water Resources Strategy Study funded by the Asian Development Bank (ADB). The MTIP contains specific projects for investment as a first stage of strategy implementation. The Plan is awaiting approval from the Federal government.

53. Sindh has prepared a Five Years Rolling Plan for 2002-2007. It includes completion of 11 on-going schemes and continuing another on-going scheme (assuring Karachi water supply and upgrading Kinjhar lake system), the work on which will spill over the five-year period. The envisaged total expenditure in respect of on-going schemes is Rs 1.04 billion (US$17.3 million). In addition there are 55 new schemes on which a total expenditure of Rs. 7.13 billion (US$118.8 million) is envisaged. Most of these schemes relate to rehabilitation/improvement of existing I&D infrastructure.

D. WATER RESOURCE CONSTRAINTS

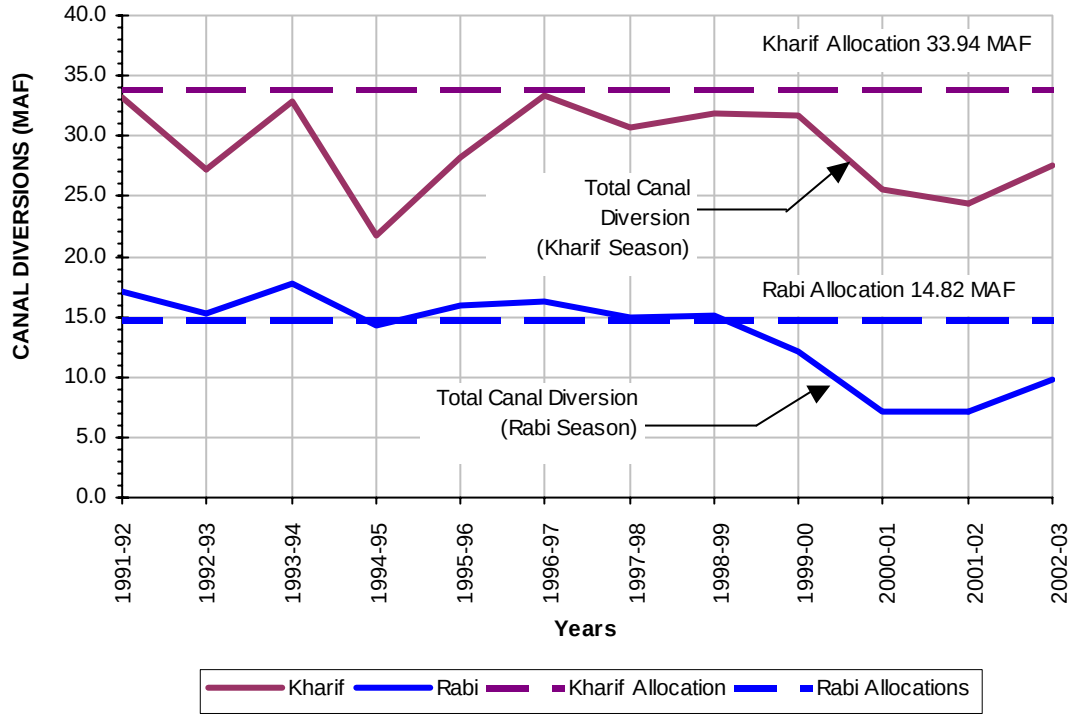
(i) Supplies

1. Climate

54. The climate of Sindh is arid and hot. Mean annual precipitation is 140 mm. In the last eleven years the rainfall varied from a low of 23 mm recorded in 1991 to a high of 468 mm in 1994. Overall the rainfall is scarce, erratic and unpredictable.

2. Water Resources

55. The Federal Government and the Provinces have agreed in 1991 on an Accord on the Apportionment of surface water among the provinces. Under the Accord Sindh's share is 60.17 Bm^3 (48.76 MAF), is 41.88 Bm^3 (33.94 MAF) in Kharif (summer) and, 18.29 Bm^3 (14.82 MAF) in Rabi (winter). The actual supplies to the province are however dependent on the water availability in the Indus System. From the following figure it is observed that except for 1994-95 and the period 1999 onwards; the province received supplies in excess of its allocation during Rabi, whereas shortages were experienced in Kharif throughout except in 1996-97. In the last few years due to drought, the Rabi supplies were also short of the allocations as the upstream reservoirs either could not be filled during summer or were drawn down in early Rabi.



56. **The Indus River** is the primary source of surface water for the province. Water availability in the Indus basin is highly seasonal with 85% of annual river flows occurring during a 90 to 120 days period (June to September). The inflows at Guddu Barrage, the first gauging point in the province, include the share of Sindh released as per the Water Accord and the surplus unutilized water in the System. Since 1991, the inflows at Guddu have varied between a high of 161 Bm^3 (131.1 MAF) and a low of 53 Bm^3 (43.4 MAF) with an average of 107 Bm^3 (87.7 MAF). On an average 89 Bm^3 (72.4 MAF) flowed in Kharif and 18.9 Bm^3 (15.4 MAF) in Rabi. During the same period the average outflow to the sea below Kotri was of the order of 44.6 Bm^3 (36.3 MAF). The outflow varied over a wide range between a low of. 0.86 Bm^3 (0.7 MAF) in 2000-2001 and a high outflow of 113.28 Bm^3 (91.8 MAF) in 1994-95.

57. In the Guddu - Sukkur reach the losses and gains generally balance each other on long term basis, however, the Sukkur – Kotri reach shows an average loss of 9.9 Bm^3 (8 MAF) in Kharif and a gain of 1.85 Bm^3 (1.5 MAF) in Rabi, showing an average loss of 8 Bm^3 (6.5 MAF) on long term basis. The causes of the high loss in Sukkur to Kotri reach need to be investigated as it reduces water availability at Kotri Barrage.

58. Due to diversions of irrigation water at the various barrages, the flow in the river decreases in downstream direction while due to disposal of the saline drainage water into the river, the salinity increases. During the dry season, the salinity at Kotri (the most downstream barrage) frequently reaches critical levels while the flow to the Arabian Sea frequently falls below ecological and sanitary requirements. During high flow, however, the discharges to the sea are quite substantial while also the salinity at Kotri is only slightly higher than the salinity at the most upstream barrages.

59. **Groundwater**. Estimates of groundwater resources have been made by different agencies at different times, which vary significantly. Estimated ground water resources for the Sindh province varies between 16 to 20 Bm^3 (13 to 16.2 MAF) with an estimates safe yield between 5.4 to 10 Bm^3 (4.4 to 8.1 MAF).

60. More than 78% of the irrigated land in Sindh is underlain with saline or brackish water, which is unfit for agriculture. The shortage of irrigation water coupled with drought conditions in Sindh and the unreliability of the canal water has increased the importance of exploitation of groundwater wherever fresh water or even saline water of marginal quality is available. Fresh groundwater is found mostly in a strip parallel to the left bank of Indus River and some pockets in other areas. Reliable data on extent of groundwater use in the province is not available. There are about 53,862 tubewells in Sindh. Of these 12,038 are public tubewells and 41,824 are in the private sector, though other unofficial estimates put the number of private tubewells much higher. The present number of tubewells is likely to be more than 70,000. Considering an operation factor of 8-10%, the groundwater pumping is estimated to be about 6 Bm^3 4.9 MAF) on an annual basis.

Number of Tubewells

Year	Public	Private	Total
1999-2000	8,470	25,191	33,661
2000-2001	9,689	27,502	37,191
2001-2002	12,038	41,824	53,862

Source: Agricultural Statistics of Pakistan.

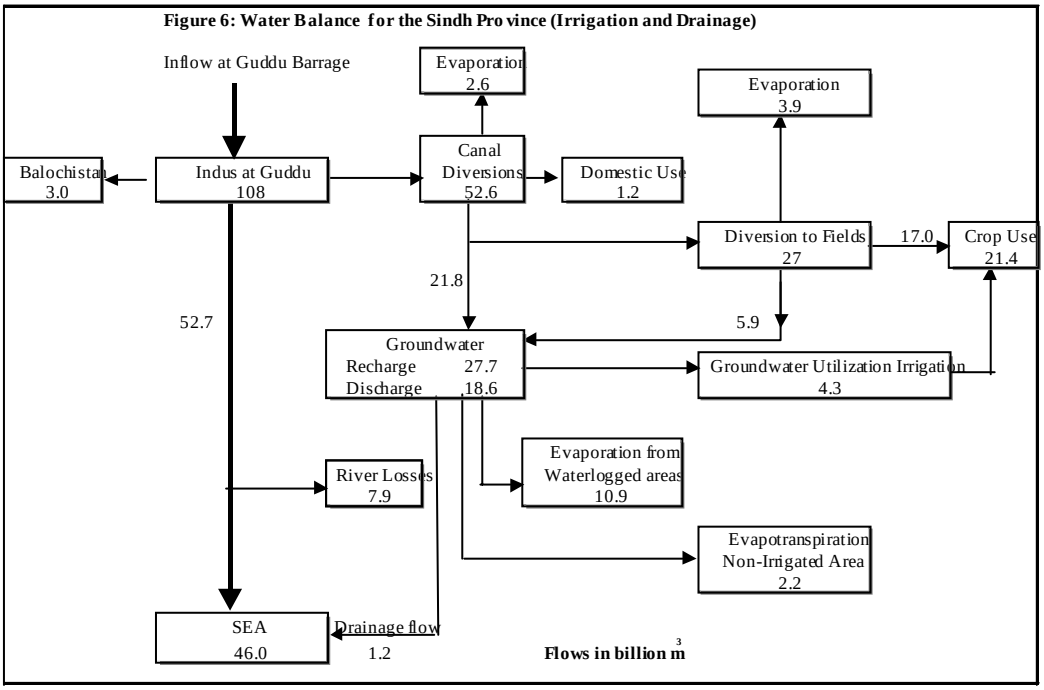
61. Some of the public tube wells are installed for drainage and pump saline water. However the private tube wells pump fresh groundwater or marginal quality groundwater, which is used for irrigation after mixing with canal water. Most of the public tube wells are not functional.

62. The quality of groundwater has been deteriorating appreciably in many cases. The groundwater resources are under the threat of seawater intrusion caused by groundwater overdraft. In the absence of hard evidence and reliable data about groundwater availability the scope for extraction of groundwater of good quality is limited in Sindh.

63. **Wetlands**. Sindh is rich with water bodies. There are 10 declared wetlands of international importance (*Ramsar* Sites) in Sindh. Most of these wetlands are directly fed by the major canals or their seepage and from rainfall. The World Wide Fund for Nature (WWF) prepared an Action Plan for Wetlands in Pakistan in August 2000.

64. **Water Balance of the Sindh Province**. An important but little appreciated fact about irrigation water use is that a substantial volume of water is recycled, thus providing a significant benefit to other consumptive users and to the environment. An attempt has been made as shown in the Figure 6 to create a water balance[1] for the Sindh province under the average conditions of inflows and canal diversions. Under average conditions the rainfall is low and does not contribute much to the crop use. As such rainfall contribution has not been considered at this stage. The areas that need firming up are: Rainfall, the losses in Sukkur-Kotri Reach, Groundwater recharge in fresh and saline areas and groundwater withdrawals including evaporation from water table from these areas and use of groundwater for agriculture. For preparing the water balance the post Water Accord data for 1991-2003 has been used.

Figure 6: Water Balance for the Sindh Province (Irrigation and Drainage)



[1] There are many very common mistakes which are made when creating water balances, including: (a) not defining the boundary of evaluation (spatially and temporally); (b) double counting of water; (c) counting all pumped water as a water supply; (d) over-estimation of recoverable seepage and deep percolation losses; (e) incorrectly assigning beneficial or non-beneficial labels to water balance. Also, a water balance has temporal (time) boundaries as well as physical boundaries, and some types of data (groundwater inflows, outflows, and change in storage; and crop ET) are difficult to evaluate accurately on a single year basis. Because all values of a water balance change from one year to another, it will be necessary to evaluate data collected over a number of years.

(ii) Demand

65. Continued rapid population growth is the single most important driving force affecting the water sector, with the increasing demands it will place on irrigated agricultural production and non-agricultural water services.

66. Sindh's population, currently about 33 million, is projected to increase to 52.6 million in 2025. The percentage of urban population will increase from the current about 50% to 64% in 2025. With the increase in life expectancy and increased migration from rural to urban areas, the whole demographic profile will undergo a major change over the next 20 years.

67. **Municipal Water Requirements**. At present Karachi has an allocation of 34,000 l/s (1,200 cusecs) from the Indus water. With increased population to about 23 million in 2025, the requirements of Karachi are expected to increase to 65,460 l/s (2,320 cusecs).

68. Similarly the municipal requirements of other urban centres will increase and will put an additional burden on water resources. The rural population mainly depends on supplies from the canal system, as groundwater in most of the areas is saline and unfit to drink. The rural population of about 18.8 million will need an additional about 7,125 l/s (250 cusecs) for drinking purposes.

69. The total municipal water requirements in the province, to be met from surface water sources in 2025 will be of the order of 94,000 l/s (about 3.300 cusecs).

70. Industrial production is concentrated in urban areas, although small-scale industries located in rural areas are spread all over the Province. Fishery in inland waters is practised as freshwater aquaculture, where fish are bred in ponds, and capture fishery in rivers and lakes. No reliable projections are available for the industrial water use.

71. **Future Water Availability**. With population growth and urbanization, need for agricultural production is expected to increase. It is estimated that by 2025 the irrigation water requirements for agriculture would increase by about 50% if the current irrigation practices continue. The current water use is about 52.6 Bm^3 (42.6 MAF). This means that an additional 26.3 Bm^3 (about 21.3 MAF) will be required to maintain the current balance between supply and demand of agriculture products. A similar increase is expected in the municipal and industrial water requirements, where about 3 Bm^3 (2.4 MAF) of additional water will be needed. As the major municipal water requirements in Sindh are met from the surface water source, these requirements will reduce the water availability for agriculture use. For meeting the water requirements in 2025 it has been estimated that an additional 29.3 Bm^3 (23.7 MAF) of water would be required

72. The groundwater use in Sindh is limited and there is little potential for groundwater markets in Sindh (Box 1)..

Box 1 : Groundwater Markets in Pakistan

1. It is generally the wealthier farmers who own groundwater irrigation equipment. In 1991, 88% of all private tubewells were owned by farmers with more than 12.5 acres. This is because of their ability to mobilise resources, credit, and government connections for electricity.
2. As a consequence of large land ownership, water sales in Sindh are low. The frequencies of sale of water vary widely between provinces (NWFP – 31.5% of owners selling water, 20.9% in Punjab, 3.7% in Balochistan and **1.2% in Sindh**).
3. Almost no farmers install tubewells with the objective of selling water, they buy to irrigate their own land and only sell the excess.
4. Groundwater volumes for sale are generally unreliable and unpredictable because it is often linked to the availability of surface water from canals.
5. The influences on the development of groundwater markets are:
   - physical environment – particularly rainfall, water quality and water depth;
   - surface irrigation – supplies of canal water directly affect need for groundwater;
   - farm characteristics – particularly farm size of owners, and degree of farm fragmentation;
   - rural development – particularly in areas of education and literacy, and population density;
   - agricultural production – cropping patterns (although this is a two way process – groundwater markets can directly influence cropping patterns too).

It has been found the most significant positive influences on tubewell density were cropping pattern (rice zones) and population density, and the most negative influence to be availability of surface water.

(after Strosser, 1997, and Meinzen-Dick, 1996).

73. There is, however, no balance between water supply and demand as the Indus Basin Irrigation System is supply based and does not have the capacity to supply water on demand. The same situation is likely to continue in future. It is therefore unrealistic to try to work out a supply and demand balance. Instead one has to optimize the water use according to the supplies and try to get more crop per drop of available water. Production of substantially higher agricultural commodities would be required to meet the needs of the population without any major increase in available water supply for irrigation. Water conservation will therefore be the key factor in improving water availability for increasing crop production.

(iii) Current Status of the Irrigation and Drainage Infrastructure

74. At the national level, in the irrigated agriculture sub sector, 67 percent of the public sector expenditures have been on the construction of new irrigation infrastructure while 33 percent has been on upkeep of the existing infrastructure. In some major water sector projects supported by donors, such as the Irrigation System Rehabilitation Projects, the On Farm Water Management Project and the ongoing National Drainage Programmes (NDP), emphasis is on rehabilitation of the irrigation and drainage infrastructure, which had deteriorated due to inadequate maintenance.

75. Due to inadequate allocations and use of O&M budgets for maintenance of water sector infrastructure has deteriorated. Also operation of the canals at higher than design discharges has resulted in deterioration of the canal system (Box 2).

Box 2: The present state of the irrigation and drainage infrastructure has been reported by PID as follows:

"---These factors compelled the operating staff to flow higher than design discharges, on a continuous basis, which has put the infrastructure under a lot of stress and strain. The canal cross-section has widened by eroding the berms and thereby weakening the canal banks. The regulators and bridges have sustained damages. Besides these changes in operating conditions, a sizable area in the command of Kotri Barrage has been subjected to coastal rainstorms on several occasions in the past, which has caused extensive damages to the irrigation and drainage systems, thus reducing the operational efficiency."

Water Distribution Inequities

76. Water distribution inequities result from excessive losses in the conveyance system, unauthorized outlets and illegal pumping from canals. Poorly maintained watercourses and minor canals have the highest incidence of illegal diversions. Direct outlets (DOs) and lift schemes from main and branch canals further contribute to inequitable distribution due to withdrawals in excess of their authorized discharges (Box 3). The main problems with direct outlets and the lift schemes are that they take water from the main and branch canals, which makes it impossible to close them. The DOs are excluded from rotation in periods of shortages and continue to withdraw water, resulting in increased shortages in the tail areas. Even when full design discharge is available at the head, rotation is needed in the system due to excessive withdrawal by the direct outlets. Except for a part of the canal commanded area where Water Boards and Farmer's Organizations have been formed, there are no effective forums for farmers to raise their concerns. Collective actions were rarely contemplated in the past to address inequities of water distribution.

Box 3: The effect of Direct Outlets (DO) on the Nara Canal

The Direct Outlets have a combined design discharge of 76 m^3/s, or 20% of the total design discharge of 388 m^3/s.These 76 m^3/s are the accumulated design discharge at the inlet of the DOs. This means that seepage or transit losses have not been accounted for. Consequently more water is needed at the Nara Headworks to supply these DOs. Due to the DOs and lift schemes, some 30% extra water is needed in the Nara Canal to be able to distribute water according to design. Unless additional water is available for meeting the demands of the DOs and lift schemes on main and branch canals, it will not be possible to ensure adequate supplies to the tail areas. The possible solution is to combine the DOs and lift schemes and feed them from new distributaries and minors constructed in parallel to the Main and Branch Canals, where possible, so that DOs and lift schemes can be supplied in rotations when necessary.

77. **Wasteful Use of Water**. Despite the overall shortages, the overuse of water in irrigation is a major problem. This is evident from low irrigation delivery and application efficiency of 35% from the canal head to crop root zone and water logging and salinity problems. Wasteful use of water stems from several factors such as; a widespread belief that more water results in higher yields, inefficient cropping patterns and wasteful agronomic practices such as plantation of rice through the *Pancho* method used in parts of Sindh, inequitable distribution and uncertainty of supplies, poorly levelled fields and flooding entire fields for irrigation purposes also result in wasteful use of water.

78. Scheduling of water is inappropriate canal deliveries generally bear little relationship with crop water requirements. In the *Kharif* (summer crop) season, when river supplies are plentiful, the water deliveries in canals often exceed crop requirements. There being few escape structures in the canal system, once water is diverted in a canal, it is delivered to watercourses and to the farms, regardless whether the crops need it or not. Under-pricing of water and inefficient systems and procedures for assessment and collection of water charges provide no incentives to farmers for improving water use efficiency.

79. **Inadequate Operation and Maintenance**. The publicly owned canal systems have deteriorated due to utilization beyond designed capacities, tampering the control structures, damage to canal banks caused by human and cattle trespassing and inadequate routine and preventive maintenance. O& M budgets fall for short of the requirements by substantial amount. Salaries of the staff and payment of power tariff for tube wells and lift pumps consume most of the budget leaving little money for maintenance works. Aside from the deterioration of conveyance channels quite a few of the major structures including barrages and head works are showing signs of ageing and long neglect, which if allowed to persist would threaten their safety.

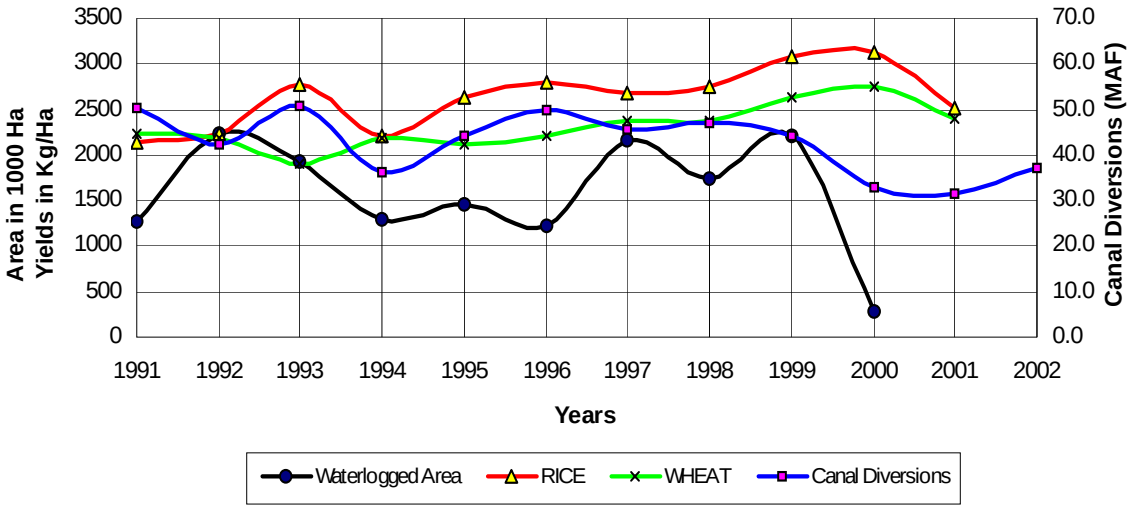
80. While there is an accumulation of deferred maintenance all over the system, smaller irrigation channels (distributaries and minors) and drains are the most neglected. In many cases, small channels operate without control structures (gates, regulators). Significant investment has been made in the past for rehabilitating the irrigation and drainage systems. An attempt was made to clear the backlog of maintenance of irrigation canals and surface drains under two Irrigation Systems Rehabilitation Projects (ISRP), implemented during 1982-94. While the program was successful in reducing the backlog of maintenance, it lacked the institutional changes needed for long-term sustainability of the system with the result that the backlog of maintenance has built up again.

81. Similar to the publicly owned canal systems, the existing drainage systems have deteriorated due to inadequate funding for O&M activities. Presently the National Drainage Programme is being implemented to rehabilitate the drainage system.

82. **Low Cost Recovery**. As already discussed there are large gaps between recoveries and O&M expenditures. Water charges and drainage cess account for less than 20% the present inadequate expenditures on O&M. The O&M expenditure is more than six times the size of the assessed revenue from water charges. The subsidy on O&M based on the assessment is constantly increasing. In 2002-2003 the O&M subsidy was of the order of Rs 3.79 billion (US$63.1 million), or Rs 744 (US$12) per ha. The ever-increasing gap between O&M expenditure and assessed water charges makes the system financially unsustainable.

83. **Waterlogging and Salinity**. There is widespread water logging and salinity in the province. Depending on the degree of water logging and soil salinity, crop yields are reduced from 25% to 60% of the potential yields in the affected areas. The water table is less than 8 feet below the surface over 37% of the area and ground water is moderately saline over 56% of the area and highly saline over 32% of the area. Existing drainage infrastructure (both surface and sub-surface) is inadequate for addressing the drainage problems satisfactorily.

84. Figure -- shows the variation in yield of wheat and rice with time as affected by water logging. The canal diversions for corresponding years are also shown so as to see the combined effect of extent of water logging and water availability on yields. The yield of wheat has gradually increased from a low of 1.9 Kg/ha in 1993 to a high of 2.7 Kg/ha in 2000 and reduced to 2.4 Kg/ha in 2001, but was still higher than the yields obtained before 1998 with much higher application of water. Similarly the yield of rice has increased from 2.2 Kg/ha in 1994 to 3 Kg/ha in 2000 but declined to 2.5 Kg/ha in 2001. The Figure – shows the positive effect of reduced water logging on the yields of wheat and rice. Higher yields of both crops were obtained with lesser amount of water, when the waterlogged area was less. This points out the need for control of water logging and at the same time for rationalization of water allowances so as to get optimum production.



Inadequate Water Availability. The average water availability to Sindh in Kharif will increase by 1.57 Bm^3 (1.28 MAF) after completion of the Rainee Canal, which is scheduled for completion in 2008. The water availability to Sindh under average inflow conditions will not exceed 60.2 Bm^3 (48.76 MAF) on an annual basis as per the Water Accord unless an additional share becomes available from the new storage reservoirs. Flows in excess of the allocated share may become available in years with above average inflows and shortages may be experienced in years with below average inflows, as has been the case in the past. Shortages in water availability in early Kharif will continue as at that time river inflows are low, irrigation requirements are high and there is insufficient water in the storage reservoirs for release. The shortages in early Kharif can be overcome only with construction of additional storages. About 4.9 Bm^3 (4 MAF) would be available from groundwater.

85. With the expected increase in the demand for supply of water for urban and rural domestic and industrial use, plus the needs of the environment, coupled with the limited overall water resources, it is likely that some water will need to be diverted from irrigation to these other uses.

86. **Unregulated Groundwater Development**. Unregulated groundwater development and pumping through private tube wells is reportedly showing stress on the aquifer in the form of excessive draw downs and deterioration of groundwater quality. The government is not doing qualitative or quantitative monitoring of groundwater.

87. **Environmental Flows below Kotri Barrage**. The downstream impacts of irrigation development such as sea intrusion, other environmental, ecological and social impacts due to reduction in surplus flows need to be studied in detail. The Para 7 of the Water Apportionment Accord states:

> *"The need for certain minimum escapage to sea below Kotri, to check sea intrusion was recognized. Sindh held the view, that the optimum level was 10 MAF (12.34 Bm^3), which was discussed at length, while other studies indicated lower or higher figures. It was therefore decided that further studies would be undertaken to establish the minimal escapage needs downstream Kotri."*

Unfortunately the studies have not been undertaken so far and there is no consensus on the escapage needs. It is now proposed to undertake these studies under the National Drainage Programme, however still there is no consensus on the Terms of reference of these studies. It may be desirable to assign these studies to an international organization like the World Bank, ADB or FAO to eliminate the element of alleged bias.

88. The quantum of water required to be released below Kotri will be decided on the basis of the above referred studies; however, there is a need to define the problems of the area below Kotri and see if other actions are also needed in addition to the releases. The problems below Kotri can be defined as: seawater intrusion; deforestation of mangroves; supply of drinking water to areas below Kotri; Irrigation supplies to the riverine area; effect on fisheries and riverine forests.

E. ALLEVIATING CONSTRAINTS

89. The amount of water available in 2025 will be well below the requirement of the agriculture sector. Efforts to improve the water situation need to be coupled with a reassessment of agricultural policy so as to increase productivity from the available water resources.

90. There are a wide range of options for improving the efficiency of water use in agriculture, including improvements in technology and equipment, institutional development, increasing water charges to encourage prudent water use and regulatory changes. While all these developments will improve agricultural water use efficiency, they are all likely to have a cost, which in many cases will include increased work by the farmer and the irrigation staff. Most of the new technology for irrigation and drainage is already known in Pakistan. The main challenge is in spreading this technology over the 5.1 million ha of irrigation in Sindh. The same is equally

true regarding institutional change, establishment of SIDA and upward adjustment of water charges.

91. There is a need to tackle the problem on several fronts, including:

- improvement in hydrological data, geographic information systems and planning;
- improving the quality of irrigation and drainage services;
- significant increase in irrigation efficiency through improved water management and modernization of irrigation and drainage systems;
- control of water logging and salinity;
- increase in agricultural productivity through greater linkage between irrigation and agriculture at policy, strategy and management levels;
- crop diversification;
- introduction of sprinkler and drip irrigation including the introduction of low-cost drip irrigation for the poverty alleviation programme;
- generation of additional water resources;
- rainwater harvesting;
- use of saline water for agriculture;
- reclamation of sodic soils;
- recycling of drainage effluent after treatment; and
- desalination for urban use.

Hydrological Data, Geographic Information Systems and Planning

92. Addressing Sindh's water resources management issues will require substantial improvement in the hydrological and water measurement networks, improvements in data bases, analytical framework and public information. By international standards, the network of water measuring stations for river flows, irrigation and drainage canals, groundwater levels, water quality and meteorology is insufficient. This inadequacy is compounded by the need to improve the quality of measuring equipment, and the methods of data collection and collation. This should be accompanied by the development of a coordinated mechanism between different agencies collecting similar data, to standardise measurement quality and measured data, and to store data in centralised data banks. Performance measurement and monitoring, including environmental aspects, is also inadequate. For instance few irrigation commands have accurate information to assess the impact of irrigation and drainage i.e. irrigation efficiencies, crop productivity and the environment, as a basis for making technological improvements for enhanced water productivity, efficiency and environmental sustainability.

93. **Planning Deficiencies**. Water sector planning is not consistent and frequent changes are needed in the plans either due to changed priorities or due to economic constraints. Availability of finances for implementation is not considered and investment priorities are not properly established.

94. The Federal government launched the TYPDP in 2001. Already the Public Sector Development Programme (PSDP) for 2003–04 shows several additions to the federal programme in Sindh. Provisions have been made for the ongoing RBOD-I and FPSP-II Projects, which were somehow left out of the TYPDP. Two new major projects have been added, which include Revamping/Rehabilitation of Irrigation and Drainage System in Sindh (Cost Rs 13 billion or US$217 million) and Lining of Irrigation Channels in Sindh (Cost Rs 25 billion or US$416.7 million). As so many projects have been started at the same time, the financial resources have to be spread out thinly and low allocations are made for different projects, which would make their timely completion difficult. The allocations for NDP, Rainee Canal, RBOD-II, Rehabilitation of Irrigation and Drainage System and Lining of Canals are on the lower side and will result in delay in completion of these projects.

95. Despite significant efforts, collection of revenues has not increased and the operation and maintenance of the irrigation system involves heavy subsidies. The quality of irrigation service delivery continues to be poor and inequitable with a pervasive public sector involvement lacking any meaningful financial or management participation of the users in operating and managing the irrigation system.

96. A holistic approach is required for water resources and drainage development in Sindh. Various plans of the federal government and the Provincial Rolling Plan need to be critically reviewed and projects prioritised with respect to their technical and economic parameters. Optimum utilization of available resources should get priority. This would not only involve rehabilitation of the existing infrastructure to improve operational efficiency, but also measures to make the distribution of water more equitable and financially sustainable. Any future planning for infrastructure improvement or expansion of facilities should include meaningful participation of users, as is being introduced through the institutional reforms under NDP, which need to be continued and strengthened.

Improving the Quality of Irrigation and Drainage Services

97. There are many problems with the operation of the irrigation and drainage system and the O&M staff of PID and SIDA are ill-equipped to operate such a complex system. There is lack of communication and availability of trained staff. The unpredictability of daily discharge in canals without any early warning system, particularly at the beginning and ends of the cropping season is a major problem. With no appreciable buffer storage behind the barrages, and a time lag approaching couple of days down to the watercourse from the barrages, the hazards of fluctuating supplies to farmers are inevitable. The agricultural consequences are of course most serious when the crops are in at a critical stage of development and irrigation demand is at its highest. The mismanagement of the system is the most frequent complaint from farmers.

98. Among the objectives of any irrigation system are to supply irrigation water adequately, equitably, reliably and in a cost-effective way. Performance targets and performance indicators are either lacking or ill defined. Matching supply with demand is perhaps the overriding

target of the PID. Quality of service targets such as equity, reliability, responsiveness and transparency are perceived as of subsidiary importance. Financial targets like unit cost of water delivered, water productivity and water charges collection rates are in general absent.

99. Experience in other countries suggests that giving farmers a role in irrigation management as part of an improved institutional framework is the key to a more productive and sustainable irrigated agriculture and increased farm income. However for WCAs to be effective and sustainable it is essential that water delivery to the WCAs is reliable, equitable, and flexible. The irrigation and drainage system to be turned over to the WUA should be in good working condition and water supply should be reliable.

100. The operation performance of the irrigation and drainage system at all levels of water demand is a most important issue and one that often receives insufficient attention. **It is recommended to improve the performance** of the main system before introducing new "on-farm" improvement programmes.

101. At present irrigation water is not delivered to the farms in an adequate and timely manner, or not delivered to the farms at the tail end of the *watercourse*, causing low yields and low farm incomes. For all the crops, the number of actual irrigations used is less than recommended. Another important result of these problems is the “head to tail effect” where the water supply gradually diminishes as it travels to plots that are further and further away from the source. Tenants at the tail ends have lower yield and, therefore, lower income. A large proportion of farmers are unwilling to pay water charges, although the charges are only a small fraction of the crop production costs. The situation has progressively worsened and results in a “vicious circle”.

Box 4: Suggested Measures for Improvement in O&M Funding

One of the options to reduce O&M liability of the government is to hand over the management of O&M activities of the tertiary system to the water users as envisaged in the institutional reforms under NDP. Until such time this option is adopted all over the province, there is a need to take suitable steps to use funding effectively in order to fill budgetary gaps and improve management. The following measures and initiatives are considered essential:

- Benchmark irrigation and drainage service provision according to the new approaches developed by IPTRID, FAO and the World Bank;
- Modernize the operation of the irrigation and drainage infrastructure through introduction of Supervisory Control and Data Acquisition (SCADA);
- Establish adequate funding levels;
- Rationalize procedures so that scarce resources at are effectively used;
- Take initiatives to establish dependable source of funding –rationalize water rates;
- Reduce management costs, improve effectiveness of expenditures and principles of accountability;
- Consider measures to improve the poor recovery of charges levied;
- Take steps to reduce exemptions of water charges by getting accepted “kharabas” for unjustified reasons;
- The operation of the channels should be reviewed to ensure that these are operated on authorized discharges (design discharges). Where these discharges are exceeded due to compelling and justified reasons the design of the channels should be properly revised (re-design channels);
- At present monitoring of the annual operation and maintenance programme is limited to financial aspects by monitoring actual releases made and liabilities incurred. It is recommended that physical monitoring indicators be developed such as; reporting number of days in irrigation seasons (separately for Kharif and Rabi) the canal authorized discharge, number of breaches occurring in a year for each type of canal (distributary, branch or main canal) level of equity in water distribution, tail shortages and reporting on problematic structures and failure of irrigation and drainage structures.

102. **The Scope and Concept of Modernization**. Modernization of irrigation systems has different interpretations depending on the background of irrigation experts. Irrigation project modernization is defined as, a process of technical and managerial upgrading (as opposed to mere

rehabilitation) of irrigation schemes combined with institutional reform, with the objective of improving resource utilisation (labour, water, economic, environment) and water delivery service to farmers. Modernisation differs from rehabilitation, which simply returns a deteriorated project or structures to their original state. Rehabilitation typically only perpetuates the vicious cycle of rehabilitation, deterioration and rehabilitation.

103. Modernization is not necessarily the conversion of an irrigation system to the state-of-the-art in technology and management. Modernization should be understood as any physical or institutional change, which would contribute to an improved service to users, to a reduced deterioration of water quality, and to a reduction of government intervention in management.

104. The scope of modernization could therefore include a large range of activities:

- operation of the main and distribution system through advanced water control structures and modern operation tools such as the Supervisory Control and Data Acquisition (SCADA);
- water application at farm level through adoption of water saving techniques;
- user participation either through transfer of management responsibilities or any other consultative approach; and
- improved administration and accounting.

Application of Advanced Irrigation Techniques

105. There is potential for reducing water use through introducing sprinkler and drip irrigation for cash crops in some areas. While it is true that capital investment and operational costs can be intensive for modern mechanized irrigation methods, consideration should be given to their introduction and a means of financing them, given the increasing scarcity of water, especially for growing high value crops such as vegetables and orchards.

Box 5: Desirable Elements in a Provential Irrigation Water Conservation Program

- A strong central organization, supported by a comprehensive code of water laws, empowered to plan and design efficient irrigation systems, allocates water, control water use and impose sanctions.
- Planning, where feasible, of regional or national grids for water distribution and joint operation of both surface water supplies and groundwater resources.
- For individual irrigation projects, well founded decisions on the design of conveyance and distribution systems (whether to select pipe or open canal systems or use both systems), taking into account the on-farm irrigation technologies to be promoted.
- Decisions should be based on long-term water supply and demand projections in the project area, as well as marketing prospects for crops.
- Implementing, with the irrigation infrastructure, a comprehensive social and economic development plan for rural areas that promotes the general well being of the population.
- Appropriate land reform and land consolidation programs to overcome land tenure problems and improve the efficiency of irrigation layouts and operation (in the main system and on-farm).
- Implementing a strong research program to develop or adapt on-farm technologies and practices for local conditions.
- A program for testing, demonstrating, and disseminating recommended technologies.
- A strong irrigation extension service (irrigation advisory service) to advise farmers on irrigation technologies, practices, and scheduling.
- A strong irrigation agronomy program to assist the irrigation extension service in determining optimal crop water requirements and developing recommendations for new cash crops.
- A program to train irrigation engineers, technicians, government workers, and water user association workers.
- An appropriate system of demand management consisting of water metering, water pricing, and possibly water allocations based on carefully researched crop water norms. A system of graduated water prices may be adopted so that the excess use of water is heavily penalized.
- Strong private sector involvement in manufacturing irrigation equipment and possibly provision of irrigation water.
- Extension services to the farmers (to be initially supported by the government if necessary).
- Quality control of irrigation equipment through standardization and issuance of quality marks for locally manufactured products by a national institute of standards.
- Access to agricultural credit so that farmers can purchase modern irrigation equipment. This may have to be subsidized initially, or may contain a grant element to provide sufficient incentive.
- The promotion of water user associations, especially where the supply of water in bulk would be possible.
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Source: World Bank Technical Paper- Improving water use in agriculture: Experiences in the Middle East and North Africa

106. **Improvement of Surface Irrigation Techniques**. In rice growing regions, there has been research into water-saving and yield-increasing techniques including surface soil moist irrigation, wastewater use, dry sowing, dry culture and paddy nurseries. Now, with the use of hybrid seed, yields have been greatly increased, together with water saving, energy saving, lodging resistance and good quality. For example, after surface soil moist irrigation methods were popularised, the efficiency of water use has in some instances increased five-fold.

107. On-demand water delivery from closed pipe systems has the potential to achieve water saving. The advantages from the application of pipe technologies are: increased irrigation command area in relation to the present command achieved mainly by water savings and better

water utilization, lower delivery system maintenance costs, improved resources management and higher water use efficiency. The disadvantages are that it requires careful design and high construction quality for effective operation. There are three types of pipeline that have been used within surface irrigation systems: a fixed pipeline in the subsoil, a moveable pipeline on the soil surface and a semi-fixed pipeline. Pipeline construction materials are many and varied and costs are coming down.

108. **Land Levelling**. The probability that major technical or operational innovations for existing surface systems will be made is low. Over the thousands of years during which surface irrigation has been practised, the alternatives for diverting the water onto the field have been clearly identified.

109. In precision land levelling, laser guidance and control applied to mechanised land levelling equipment has increased accuracy by at least a factor of 10 and results are impressive in terms of efficiency and production. Laser levelling both increases yields and decreases costs for irrigation water. The impact of levelling on crop yield and water use varies widely depending on the previous irrigation method crop and soil. In general, yield gains can be in the range of 30-50% and water savings 10-25%. However, where water fees are not based on volume of water used, the incentive to save water is missing and it would be doubtful that increases in yield alone would repay the cost of levelling.

110. **Plastic Film Mulch**. Research in respect to water saving and yield increases from plastic film mulching have been carried out by studying crop root development, photosynthesis, yield formation, nutrient absorption, evapotranspiration and the comprehensive effects of field micro-climate. Plastic film mulching has developed very rapidly in China. It has been applied successfully to 88 crops, including vegetables, cotton, peanuts, rice, tobacco, wheat and maize. The water saving and yield increasing effects have been remarkable. The treated area has reached more than 1.3 million ha and is the highest for any country in the world. Many kinds of plastic film and machines for mulching plastic film have been investigated and produced successfully. In Xinjiang province, techniques for irrigation using plastic film have been investigated for cotton. Compared with no plastic film, water savings of 72% have been achieved.

111. **Stubble Mulching**. In many provinces in China soil has been mulched with wheat straw during the fallow and crop growing periods. Ineffective evaporation was decreased and the water saving effects were remarkable. At the same yield level, the stubble mulching saved 23%, 14% and 30% of water for winter wheat, summer maize and cotton, respectively.

Generation of Additional Water Resources

112. There is a need for generation of additional water resources both through conventional (additional diversion capacity in Kharif and/or storage) and non-conventional means including:

- rainwater harvesting;
- use of saline water for agriculture;
- recycling of drainage effluent after treatment; and
- desalination for urban use.

113. **Rainwater Harvesting**. Rainwater is generally wasted, unless it flows into streams and is picked up downstream. There are very few sites for storage of rainwater. In addition to storage of rainwater, there is the possibility of harvesting rain to spread its benefit over somewhat longer periods.

114. One mode of rain harvesting which is used in Pakistan in watersheds of hill torrents and small streams is through construction of check dams to retard the speed of flows and construction of delay action dams to flatten the flood peaks and use the runoff either for recharging the groundwater aquifer or to divert it into channels for use in flood irrigation. This technique has become popular in the water scarce areas of Balochistan, NWFP and parts of Punjab. The Master Feasibility Studies for Flood Management of Hill Torrents of Pakistan, prepared by NESPAK in 1998 identified three hill torrent areas in Sindh. The runoff estimation for these hill torrents is shown in the following table

Runoff Potential of Hill Torrents in Sindh

Description	Khirther Range	Karachi Area	Sehwan and Petaro Area	Total
Average Annual Rainfall, inches	6.1	8.1	8.1	**7.4**
Catchment Area sq. miles	6,215	1,363	5,095	**12,672**
Average Annual Runoff MAF	0.296	0.094	0.33	**0.720**
Average Annual Runoff Bm^3	0.36	0.116	0.407	**0.89**

Already some projects including Gaj Nai Dam, Detention weirs on Malir River in Karachi and Mol Dam have been planned for tapping this source.

115. In urban and rural areas collecting rainwater from rooftops through drainpipes into a pit can be used for rainwater harvesting. In this case the area around the pit is sloped so that water from the environs also flows easily into the pit. The pit has layers of sand, pebbles and broken bricks for good filtration. While this in itself will improve the ground water table, open wells may be sunk, into which a PVC pipe can conduct water from the pit. The terraces and roofs of houses and building complexes can be converted into catchment areas for rainwater by this simple technique. Rain harvesting can also be introduced in public and community wells situated near slums and in villages, draining water from nearby rooftops and streets.

116. **Use of Saline Water for Agriculture**. The use of saline water for cropping is restricted to growing salt resistant crops. Such crops as grasses for fodder, bushes and trees have proved successful in other areas in providing a reasonable economic return from areas affected by saline soils or using saline water for irrigation. While this may not have a widespread benefit, there is likely a potential for local improvements in farmer income.

117. The Pakistan Atomic Energy Commission has been conducting research for the last 20 years for developing techniques for using saline lands and brackish water. The technique involves growing of salt tolerant plants using brackish water rather than reclaiming the land for growing conventional crops by using fresh water. The approach is evolution of highly salt tolerant species through breeding, wide hybridisation and other biotechnological techniques. It is reported that by using this technique, annual returns of about Rs 15,000/acre (US$617/ha) are possible.

The technique will produce timber, fodder and forage and will result in higher livestock production. Similar research carried out by the International Waterlogging and Salinity Research Institute (IWASRI) has indicated that saline effluent can be used for increasing crop production without affecting the soil productivity. The results of these researches need to be reviewed and disseminated to farmers in areas without access to fresh water who may be encouraged to adopt these techniques.

118. **Recycling of Wastewater Effluents after Treatment**. There is potential to re-use wastewater effluent either for irrigation or groundwater recharge. However, care must be taken to ensure that the effluent is treated before use for irrigating food crops. While this should be considered in future water sector strategies, given the poor performance of wastewater treatment and disposal to date, recycling must be considered with caution. Even otherwise treatment of wastewater effluent needs to be given priority from the environmental and water quality concerns. Karachi has three wastewater treatment plants with a design capacity of 151 mgd. The KW&SB is planning for utilization of treated effluent from one of the plants.

119. **Desalination for Urban Use**. Desalination of seawater or brackish groundwater for use in urban water supplies is expensive because of high-energy costs. Desalinated water is of comparatively high quality and the benefit of not having to treat the water so extensively may offset the higher cost of the desalination process. Especially for coastal cities, such as Karachi, and inland cities, which have access to brackish groundwater, there is potential to benefit from desalinated water, which should be investigated as a possible future source. The Pakistan Atomic Energy Commission is experimenting to develop cheaper technologies for desalination and has installed a desalination plant for meeting the fresh water needs of KANUPP in Karachi using reverse osmosis.

120. **Reclamation of Sodic Soils**. Saline-sodic soils need a special treatment because simple leaching and drainage does not solve the problem. Treatment with gypsum is quite effective for reclamation of saline-sodic soils. Government had initially provided a subsidy to promote the use of gypsum but this has since been withdrawn.

Demand Management

121. For the foreseeable future, cropping patterns are likely to be decided by a mixture of market forces and government direction such as in adequate production of grain staples and strategic cash crops, such as cotton. For these crops the level of the water charge will, therefore, only encourage careful water use, but would not directly influence the area to be planted. For all other crops water charges could provide a means of influencing cropping patterns through a higher water tariff for crops with a high water demand.

122. In order to operate a system of volumetric charging, measuring devices will be required, ideally at each turnout. Installation of measuring devices from the offtake at each bifurcation through to the field channel will be important for system management and to monitor system losses.

123. As well as demand management through water pricing and cropping pattern adjustment, correct irrigation scheduling will be important. This will allow irrigation to be managed so as to meet crop requirements over the whole system (including tail end canal areas)

while at the same time overcoming or flattening peak demand and allowing adequate periods for system maintenance. Irrigation scheduling involves relatively small investment costs but increases operating costs. Short-term benefits are unlikely to be as dramatic as those achieved by lining, but long-term it can be of considerable benefit in improving water use efficiency and providing for flexibility in system management. There can also be other advantages in reduced canal maintenance and improved quality of drainage and return flows. Computer management systems, such as FAO's CROPWAT and Tensiometers are available to assist in the design of irrigation schedules.

124. Remote sensing can be of considerable assistance in system management, making it possible to prepare a quantitative analysis of the problems associated with poor water distribution. Inadequate distribution is clearly reflected in differences in cropping patterns, cropping intensities and crop development along the irrigation canals. Data on cropping patterns are traditionally collected through surveys and inquiries addressed to farmers. They are often not completely reliable and only valid for sample areas. With RS land use data can be obtained for large irrigation districts. The images may provide not only a general overview but also give an indication of problem areas with salt-affected soils and inadequacies in water supply (due, for example, to the distance from primary canals). Overall costs of a full remote sensing and mapping programme are US$18/km^2/year.

Estimates of Water Saving from Improved Efficiency

125. Irrigation use at present does not face much competition from other sub-sectors but will face major competition from the municipal and industrial water supply sub-sectors in future. There is a need to vigorously pursue water conservation measures through watercourse improvement, lining of distributaries and minors in saline groundwater areas, land levelling and adoption of drip and sprinkler irrigation where feasible. With these measures about 40-41% efficiency should be targeted for 2010-2011 based on 90% efficiency for Main and Branch Canals, 86% for distributaries and minor canals, 75% for watercourses and 70% in field application. The corresponding conveyance efficiency up to the farm turn out will improve to 58%. With improved efficiency, the total losses will be reduced by about 5% making about 1.7 Bm^3 of extra water available for crop use.

126. By 2025, the target for improved efficiency may be fixed at 45%. This can be achieved by undertaking investments and adopting application techniques targeted at achieving higher efficiency for water conveyance and field application. By adopting these measures the cropped area can be increased by about 12% of the present area or by about 400,000 ha.

Potential Water Savings from Improved Efficiencies

Description	Current Situation		Improved Situation 2025	
	Availability	Losses	Availability	Losses
Canal Head Diversion MAF	42.62	4.26	42.62	4.26
Distributaries/Minors Head MAF	38.36	5.75	38.36	3.84
Watercourse Head MAF	32.61	9.78	34.52	7.94
Field Application MAF	22.83	7.99	26.58	7.44
Crop Use MAF	14.84		19.14	
Efficiency % (estimated)	35%		45%	
Total Loss MAF		27.79		23.48
Water Saved MAF			4.31	
Note: 1 (MAF) million acre foot is equal to 1.234 billion cubic metre.				

Estimated Costs for Rehabilitation and Modernization

127. For saving the 5.32 BM^3 (4.31 MAF) of water through improved efficiency following measures will be required.

- improvement in field application efficiency by 7%;
- improvement in watercourse efficiency by 7%;
- improvement in efficiency of distributary and minor canals by 5%; and
- proper maintenance of main and branch canals.

128. **Cost of Improvement in Field Efficiency**. Field application efficiency improvements will come mainly from Laser land levelling. About 20 to 25% of the loss is reduced from land levelling. The present loss of 9.9 BM^3 (8 MAF) takes place from an average cropped area of 3.785 Mha. For reducing the overall loss by 7% land levelling is required over 1.4 Mha area to cover the existing as well as the expected increased area brought under cultivation due to water saving. Land levelling operation will have to be carried out every 3 to 5 years to get continued benefits. This would mean that every year about 250,000 to 300,000 ha would need to be levelled. One Laser equipment, on average levels about 1,000 ha/year; as such about 2700 laser levelling equipments will be required to be in operation. The present cost of the laser equipment with scraper and tractor is about Rs 750,000. It would require an investment of Rs 2 Billion every 5 years. Total capital cost over the 20-year period will be of the order of Rs 8 Billion. For operating the Laser equipment the running costs to cover the fuel cost, operator and repairs etc about Rs 400,000/year are required for each equipment. The total annual O&M cost will be about Rs 1.1 billion and Rs 22 billion over the 20-year period. The total cost for improving the field efficiency by 7% over the 20-year period will be of the order of Rs 30 billion.

129. Laser technology for PLL has been introduced in Sindh under On-Farm Water Management projects. To introduce this technology in Sindh, 24 Laser Units were procured under OFWMP-III and 5 under Japan sponsored OFWM Project for demonstration purpose only. However, because of limited availability, only a few demonstrations could be carried out. The Sindh OFWM Project is envisaging land levelling of 40,000 ha over a 4-year period. 150 laser land levelling equipments would be procured and handed over to the FOs / WCAs on cost sharing basis (50% of capital cost) to undertake PLL on their farms. FOs will provide the tractors and will

be responsible for the O&M costs. If the same model is adopted for the PLL operations then the Government will be required to pay a subsidy of about Rs 4 billion, whereas the farmers would have to pay the remaining Rs 26 billion (Rs 4 billion for capital cost and Rs 22 billion for O&M costs). Such a large investment by the farmers is highly unlikely and it may prove difficult to improve overall field application efficiency by 7%.

130. **Improvement in Watercourse Efficiency**. There are about 43,000 watercourses in Sindh that carry an average discharge of about 40.2 BM^3 (32.6 MAF) annually. The average discharge conveyed by a watercourse is of the order of 86 to 123 M^3 (70 to 100 AF) annually. Improvement of watercourses is estimated to save about 40% of the loss in the watercourse. For improving the overall efficiency by 7%, improvement of about 25,000 watercourses would be required. The Sindh On-Farm water Management Project envisages improvement of 4,000 watercourses in 4 years at a cost of about Rs 3.6 billion. The cost of improving an additional 21,000 watercourses will be about Rs 19 billion. As such the total cost of watercourse improvement from 2004-2025 would be about Rs 22.6 billion. In addition, there will be a need to rehabilitate at least about 5,000 already improved watercourses, which would deteriorate with time and would cost another about Rs 4.5 billion. Accordingly the total cost for improving the watercourse conveyance efficiency by 7% will be of the order of RS 27 Billion. As about 50% cost of watercourse improvement is borne by the Government and 50% by the beneficiaries, the cost to the Government will be about Rs 13.5 billion whereas the farmers will have to pay remaining Rs 13.5 billion.

131. **Improvement in Efficiency of Distributary and Minor Canals**. For attaining the overall efficiency of 45% the efficiency of Distributary and Minor Canals will need to be improved by 5%. This will need lining of some distributaries and minors, where the losses are high in addition to other improvement works similar to those envisaged under the Revamping/Rehabilitation of Irrigation and Drainage System Project. Works would include: (a) Strengthening banks; (b) Silt clearance; (c) Repair/Replacement of regulators and gates; (e) Repairs of Modules; (f) Revamping of telecommunication system on canal network; and (g) Stone pitching in vulnerable canal prisms. The current Revamping Project mainly relates to ensuring present supplies in Rabi and increasing the Kharif supplies through increase of carrying capacity of the canals mainly through desilting. Improvement of efficiency of the conveyance system is not targeted. The Project cost of Rs 13 billion translates to a cost of Rs 2,549/ha of CCA. The cost of rehabilitation of the distributary and minors including lining of critical reaches will be of the order of Rs 8,000/ha or about Rs 40 Billion. As is proposed in Sindh On-Farm Water Management Project, 5% of the rehabilitation/improvement cost is to be borne by the beneficiaries. If the same arrangement is followed, then the farmers' share will amount to Rs 2 Billion and the Government share will amount to Rs 38 Billion.

132. **Improvement in Efficiency of Main and Branch Canals**. For attaining the overall efficiency of 45%, no improvement in the conveyance efficiency of Main and Branch Canals has been considered. However in order to maintain the conveyance efficiency of the canal system at present level proper O&M or periodic rehabilitation would be required. This will need improvement works similar to those envisaged under the Revamping/Rehabilitation of Irrigation and Drainage System Project. Works would include: (a) Strengthening banks; (b) Silt clearance; (c) Repair/Replacement of regulators and gates; (e) Repairs of Modules; (f) Revamping of telecommunication system on canal network; and (g) Stone pitching in vulnerable canal prisms. Construction of Sehwan Barrage will result in saving in the losses in the Upper Nara and Rohri

Canals. The cost of periodic rehabilitation of the Branch and Main Canals for improving their conveyance efficiency is estimated at about Rs 5 billion/every 5 years or Rs 20 billion over the next 20 years.

133. **Rehabilitation and Modernization of Barrages**. In order to ensure the continued safe functioning of the 3 barrages there will be a need for rehabilitation and modernization of the barrages. Sukkur Barrage commissioned in 1932 provides one of the largest irrigation network in the world, commands an area of 3.033 million hectares (7.492 million acres). Guddu Barrage, was commissioned in 1962 and commands an area of 0.88 million hectares (2.18 million acres). Kotri Barrage commissioned in 1955 commands an area of 1.17 million hectares (2.9 million acres) and also diverts drinking water for Karachi. Though the gates of Sukkur and Kotri Barrages have been replaced, yet all the 3 barrages suffer from inadequate regular maintenance, rendering them prone to catastrophic damage at any time. Failure of any of the main hydraulic structures would have dramatic consequences in terms of lost agricultural production, misery caused to the people who depend on them for their livelihoods and flood damage. It is recommended that a condition survey of the 3 barrages may be undertaken to ascertain the rehabilitation and modernization needs.

134. **Total Estimated Cost for Improving Efficiency**. The total cost for water conservation measures aimed at saving about 5.32 BM^3 (4.31 MAF) by 2025 is estimated as Rs 117 billion (US$1.95 billion) and is summarized in following table. An estimated Rs 65.5 billion (US$1.09 billion) will be needed in the public sector whereas some Rs 41.5 billion (US$0.69 billion) will need to be invested by the farmers.

Estimated Cost for Improving Irrigation Efficiency
Cost in Rs Billion

Component	Total Cost	Government Share	Farmers Share
Land Levelling	30	4.0	26.0
Watercourse Improvement	27	13.5	13.5
Distributary Improvement	40	38.0	2.0
Main and Branch Canals Improvement	20	20.0	0
Total Estimated Cost	**117**	**75.5**	**41.5**
Planned Conservation Projects			
Sindh OFWM Project	5	2.5	2.5
Lining of Canals	25	25	0
Sub-total planned projects	**30**	**27.5**	**2.5**
Total Additional Cost	**87**	**48.5**	**39**

135. The above cost does not include the cost of rehabilitation and modernization of the barrages as well as full-scale rehabilitation of main and branch canals. After accounting for the Sindh On-Farm Water Management Project, which would be implemented over the next 4 years, and the project for lining of canals costing Rs 25 billion, the total cost of additional water conservation measures will be Rs 87 billion, Rs 48.5 billion in public sector and Rs 39 billion to be borne by the farmers.

Optimising the Bank's Role in Water and Irrigation and Drainage Policy Reform

136. The Bank can play a very useful role in helping to overcome the problem of conflicting interests between separate provinces and to see the essential importance of water resource planning and management on a basin-wide basis. The studies on environmental flows and continued support for the change towards greater decentralisation will be of particular importance. In its policy dialogue with Government, the Bank benefits from being able to give objective and unbiased advice. It is also able to draw on experience world-wide, which in the past has been of great advantage to the Pakistani water professionals and is able to marshal appropriate and well qualified specialists with first hand experience of problem solving and novel technologies in other countries.

Investments (Programme versus Project, Software versus Hardware)

137. Irrigation and drainage systems to be financed must be selected on the basis of rapidity of payback or economic rate of return. So long as disbursement of funds can be carefully monitored to ensure that items of infrastructure to be modernized are properly identified and that funds are correctly applied, a programme approach would appear preferable. Bank involvement in provision of finance for new dam construction would be subject to satisfactory environmental evaluation.

138. In the choice of items to finance it would generally be the case that investments in the on-going institutional change accompanied by irrigation and drainage modernization programme for better water management would show the highest benefits and fastest payback. This would be due to the likelihood of relatively low investment costs relative to benefits, which could be made even more attractive if the changes resulted in greater mobilisation of savings of the beneficiaries. In scheme improvement allowance should be made for the cost of installation of measuring flumes or other devices that would facilitate water charges to be levied on a volumetric basis.

139. **Technical Assistance**. Provision of technical assistance by the World Bank would be useful in: hydrology and water sector planning; environmental flows; drainage accord; and a modernization programme for the irrigation and drainage sub-sector to support the on-going irrigation management transfer (Attachment 2 provides the logical framework including the tasks/inputs schedule for an irrigation and drainage modernization programme to support SIDA in the delivery of irrigation and drainage services).

ATTACHMENT 1

SUMMARY AND FRAMEWORK OF THE PAKISTAN WATER SECTOR STRATEGY

Sub Sector		Water Resources	Urban Water Supply and Sanitation	Rural Water Supply and Sanitation	Industrial Water Supply and Pollution Control	Irrigation and Drainage	Hydropower	Environment	Flood Protection
OBJECTIVES	**Overall**	**To achieve the National Water Vision:** *By 2025, Pakistan should have adequate water available, through proper conservation and development. Water supplies should be of good quality, equitably distributed and meet the needs of all users through an efficient management, institutional and legal system that would ensure the sustainable utilization of the water resources and support economic and social development with due consideration to the environment, quality of life, economic value of resources, ability to pay and participation of all stakeholders.*							
	Sectoral	1. Provide sufficient water for all sub sectors based on Integrated Water Resources Management (IWRM) 2. Promote water conservation. 3. Ensure effective planning and decision making 4. Regulate groundwater abstraction where feasible 5. Improve water quality 6. Develop information base 7. Develop public awareness and understanding of the issues	1. Provide water supply to 96% of urban population 2. Provide functional sewerage to 80% of the urban population 3. Achieve financial sustainability in all urban water developments 4. Achieve full compliance with EPA standards for drinking water and wastewater disposal 5. Develop water quality information management system	1. Increase rural water supply coverage to 75% of the population 2. Increase coverage of rural sanitation to 50% 3. Improve drinking water quality to comply with EPA standards 4. Ensure services are financial self sustaining 5. Develop a comprehensive water quality monitoring and information system 6. Raise public awareness re: hygiene and sanitation	1. Ensure provision of sufficient water to industry to promote industrial and economic development 2. Ensure environmentally sound disposal of industrial waste water through regulation, in order to reduce pollution and improve water quality	1. Increase irrigation efficiency from 40% to 45% to conserve 4.7 MAF 2. Achieve equity in water distribution at all levels 3. Harness unused flood water and runoff from hill torrents 4. Increase irrigated agriculture over 2 million acres of culturable waste for agricultural production and poverty alleviation 5. Achieve sustainability including financial sustainability 6. Promote stakeholder participation, through PIDAs, AWBs and FOs 7. Reduce waterlogging in 7 million acres 8. Provide a long term safe solution for saline drainage effluent	1. Develop the hydropower sub-sector in parallel with the overall power sector 2. Attract private investment 3. Develop the hydropower potential of any new multipurpose storage projects 4. Develop run-of-river hydro projects through private sector finance.	1. Improve the quality of surface and ground water to acceptable standards by 2025. 2. Rehabilitate coastal and other wetland areas through better management of freshwater flows to them. 3. Reduce soil erosion in the catchments of major storage reservoirs.	1. Place priority for flood protection on areas of major human habitation and economic importance 2. Prepare flood and drought management strategies, especially for major cities, towns and infrastructure 3. Promote the delineation of flood risk planning zones to be adopted by all agencies as part of the planning process
STRATEGY	**Overall**	• Ministry Water and Power to obtain formal adoption, initially from the Economic Coordinating Committee and, subsequently, the Cabinet for the Water Sector Strategy. • Establish an inter-ministerial, inter-provincial National Water Council with a supporting Apex Body established within the Ministry of Water and Power to oversee the planning, development and management of the water sector, beginning with the implementation of the Strategy. Determine capacity building needs and begin capacity building process. • Extend the charter of Ministry Water and Power to include all sub-sectors of the water sector • Undertake an Integrated Water Resources Master Plan, with emphasis on conservation, storage and environmental needs							

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	Sectoral								
	Short Term 2003 & 2004	• Promote and support water sector conservation • Commit to develop storage • Prepare water resources master plan • Undertake feasibility study on public awareness • Study and develop a water sector Management Information System (MIS) • Develop water quality monitoring programme	• Develop coordinating and support body for the urban water sector • Develop long term plans for water and sanitation services • Restructure sub-sector financing, tariff mechanisms and regulation • Address maintenance backlog • Develop water resources to maintain continuity of supply to existing customers • Improve revenue recovery	• Undertake project preparation • Establish Project Management Units (PMUs) in each Province • Train PMU staff and Community Based Organisation (CBO) personnel • Develop and execute public awareness campaigns.	• Assess the need for financial incentives to industries to comply with EPA effluent disposal regulations • Determine legislative needs for regulation of industries and enforcement of standards and water abstraction licensing. • Undertake a feasibility study to develop a water quality monitoring programme • Develop an awareness campaign to promote the reduction of pollution • Prepare a national industrial pollution control plan	• Commit to financial sustainability of the irrigation & drainage infrastructure and prepare a plan for this • Initiate actions to increase irrigation efficiency to 45% - to include addressing improved water management, farmer participation and cost recovery • Assess benefits of lining distributaries in saline areas and develop plan • Prepare plan to modernise barrages and the feasibility studies for priority works • Restructure NDP • Complete pre-feasibility study for spinal drain • Prepare plan to harness hill torrent flows • Prepare plan for expansion of agricultural area • Prepare/upgrade feasibility studies for small schemes • Complete regulations for groundwater abstraction	• For large storage dams, the hydro strategy follows that for water resources and the national power plan • For smaller run of river schemes, develop a private investment enabling environment	• Plan a comprehensive national water quality management programme • Develop a major campaign to raise public awareness of the environment • Support the studies to determine the volume of flows required downstream of Kotri • Assess the need for incentives to industries to comply with EPA effluent disposal regulations • Determine the needs for legislation for regulation of industrial development, enforcement of standards and water abstraction licensing	• Restart the Second Flood Protection Sector Project, including non physical works and studies, which are important to a holistic approach to flood protection. • Following the Second Flood Sector Project, implement the proposed Third Flood Sector Project

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	Medium Term 2005 – 2011	• Promote and support water conservation • Implement water resources master plan and begin implementation of storage development • Implement public awareness programme • Develop MIS • Implement Water Quality improvement programme	• Develop water resources to meet projected new demand and consumption • Extend networks to increase service coverage • Achieve compliance with drinking water quality and effluent discharge standards • Possible reorientation of Coordinating and Support body to Regulating Body if private sector investment improves	• Establish water quality testing laboratories • Assist communities to form CBOs • Undertake rehabilitation programme for existing schemes • Phase 1 development of new schemes	• Enact new legislation for industrial effluent control • Develop and implement a water quality monitoring programme • Execute public awareness campaign • Execute National Industrial Pollution Control Plan, including, public private partnership approach to pollution control	• Undertake training/capacity building to strengthen PIDAs and AWBs • Implement pilot projects for development of stakeholder participation and then expand • Initiate pilot projects to evaluate modern irrigation technologies • Expand the on farm water management programme (OFWM) • Independently monitor and evaluate the OFWM programmes • Line distributaries in saline GW areas • Implement modernisation of barrages • Rehabilitate/improve existing irrigation systems • Prepare studies for modernisation of 2nd priority barrages • Complete revised NDP I • Prepare NDPs II and III and complete NDP II, inc. the spinal drain • Plan increased cropping intensity as new storage comes on line		• Implement the national water quality monitoring programme • Execute the public awareness campaign on the environment • Support municipal and industrial waste water control measures • Improve urban and rural solid waste management to a coverage of 55% • Enact new legislation where required	

Sub Sector		Water Resources	Urban Water Supply and Sanitation	Rural Water Supply and Sanitation	Industrial Water Supply and Pollution Control	Irrigation and Drainage	Hydropower	Environment	Flood Protection
	Long Term 2012 – 2025	• Promote and support water conservation • Implement storage projects • Maintain effective public awareness programme • Continue updating MIS • Update and improve water quality improvement programme	• Continuation of development of water resources • Continuation of extension of networks • Continuation of programme to achieve compliance in drinking water and effluent quality standards	• Phase 2 development of new schemes	• Continue to improve monitoring programme • Monitor and evaluate the National Industrial Pollution Control Plan	• Extend implementation of stakeholder participation to entire network • Introduce new technologies with the participation of the farmers • Expand OFWM programme to all watercourses • Continue to monitor saved water • Continue lining of distributaries in saline areas • Continue rehab/improvement of the existing irrigation system • Continue modernisation of second priority barrages • Carry out NDP III including completion of the spinal drain • Implement crop intensification programme		• Monitor, evaluate and improve the national water quality management programme • Continue a reduced public awareness campaign • Continue improvement of urban and rural solid waste management with coverage increasing to 90%	
Cost US$ Million	**Total = 33,622**	10,000	5,066	2,173	253	11,099	4,500	113	418
	OVERALL	Overall responsibility for the implementation of the Strategy will be with the National Water Council, supported by an Apex Body to be established and developed to necessary capacity within the Ministry of Water and Power.							
	FEDERAL	**NATIONAL WATER COUNCIL** **MINISTRY OF WATER AND POWER** IRSA	Proposed Coordination and Support Body for urban water supply.	Planning Commission	Pakistan Environmental Protection Agency (EPA)	Proposed National Drainage Authority	Min of Water and Power Water Wing of WAPDA Private Power Investment Board	Pakistan Environmental Protection Agency	Federal Flood Commission

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	PROVINCIAL	Planning and Development Departments	KWSB, WASAs, District Councils, Private Sector	Public Health Engineering Departments and District and Tehsil Councils	Provincial Environmental Protection Departments (Agencies)	PIDAs, AWBs and FOs	NWFP and AJK Private Power Cells Plus the Private Sector	Provincial Environmental Protection Departments (Agencies)	Provincial Irrigation Departments
PRIORITY		To be accorded special priority and funding	Top priority	Top priority	Licensing and pollution control measures to be given priority	Priority accorded to conservation, modernisation of existing infrastructure, small schemes for poverty reduction, intensification of cropping	Major schemes with major storage, small schemes through private finance	Equal priority to water supply and sanitation, particular emphasis on water quality and pollution control	Second priority, as a result of risk to life
SECTORAL CONSTRAINTS		1. Time 2. Slow growth in Water Sector Development 3. Project implementation difficulties 4. Finances	1. Lack of institutional arrangements 2. Lack of consistent approach to funding and regulation 3. Low tariffs and collection rates 4. Non commercial approach to service delivery 5. Poor climate to attract private sector	1. Poor and deteriorating water quality at source and within systems 2. Variable history of community involvement 3. Uncertain impact of devolution plan	1. Inadequate monitoring of industrial effluent 2. Inability to enforce existing effluent quality regulations 3. Inability of industries to finance on-site effluent treatment to comply with regulations.	1. Poor project implementation 2. Scarcity of water 3. Lack of consensus and cooperation 4. Poor information availability 5. Overuse of water in some areas and lack of effort in conservation 6. Design of the irrigation systems 7. Inequitable distribution of water 8. Low cost recovery and poor maintenance 9. Weakness of institutions 10. Lack of stakeholder participation	1. Consensus and government policy 2. Finances 3. Poor private sector investment climate 4. Legal and regulatory issues	1. Low priority accorded to water quality 2. Inadequate institutional capacity to implement effective pollution control 3. Insufficient funding 4. Governance problems 5. Existing legislation is punitive rather than cooperative 6. Planning is poor and tends to be over ambitious 7. Poor stakeholder and private sector participation	1. Stalling of the Second Flood Protection Sector Project 2. Lack of support for a realistic and holistic approach to flood protection

Sub Sector	Water Resources	Urban Water Supply and Sanitation	Rural Water Supply and Sanitation	Industrial Water Supply and Pollution Control	Irrigation and Drainage	Hydropower	Environment	Flood Protection
OVERALL ISSUES	**Management:** (1) Lack of financial sustainability, (2) Inadequate cost recovery, (3) Ineffective public sector management of water sector infrastructure and activities, (4) Limited stakeholder participation, (5) Poor public awareness, (6) Poor water information, (7) No private sector investment or participation, (8) inadequate cost recovery. **Technical:** (1) Increasing demand for water, (2) Deteriorating water quality, (3) Inadequate domestic water supply and sanitation, coverage and quality of service, (4) Deteriorating irrigation and drainage infrastructure, (5) Waterlogging and salinity on irrigated land and disposal of saline drainage effluent.							

ATTACHMENT 2

LOGICAL FRAMEWORK FOR AN IRRIGATION AND DRAINAGE MODERNIZATION PROGRAMME

	Intervention Logic	Objectively Verifiable Indicators	Means of Verification	Assumptions
Overall Objectives	Modernizing water delivery and irrigation and drainage infrastructure to enable and support the institutional change objectives. Improved delivery of irrigation and drainage service to 2.2 million hectares and more efficient water use. To increase and sustain agricultural production and farmers' incomes and to strengthen the capacity of the Sindh Irrigation and Drainage Authority in delivery of irrigation and drainage service and for undertaking other similar projects in future	Increased cropping intensity and yields in the selected command areas. SIDA continues with better irrigation service without external technical assistance.	Irrigation and Drainage service delivery; Recovery of water charges. Benchmarks of external and internal performance indicators of irrigation and drainage systems. Annual M&E reports. Supervision missions.	SIDA as implementing agency Agricultural input and output prices remain stable
Immediate Objectives	(a) strengthening cost recovery form irrigation and drainage beneficiaries in direct support of O&M expenditure and encouraging the efficient use of water resources. (b) supporting the on-going institutional reforms and decentralisation effort through strengthening the roles and responsibilities of SIDA, Area Water Boards and Farmers organization. (c) modernizing the irrigation and drainage systems, programming, GIS, budgeting and institutional aspects of O&M, so that the effectiveness of existing systems can be sustained.	Improving the performance of the main systems. Improvement works, including provision of water control and measurement structures and the Supervisory and carried out in the selected command areas. Water user organisations responsible and actively involved in O&M. Baseline and follow surveys completed for representative sample areas within commands. Mitigation plan for institutional weaknesses operational.	Irrigation and Drainage service delivery; Recovery of water charges. Benchmarks of external and internal performance indicators of irrigation and drainage systems. Annual M&E reports. Supervision missions.	Government commitment to PIM.

	Intervention Logic	Objectively Verifiable Indicators	Means of Verification	Assumptions
Results	Modernisation and rehabilitation of main conveyance network and the provision of water control structures and/or parallel distributary canals for feeding the direct outlets and lift schemes and SCADA in the command areas of SIDA. Hence improved irrigation distribution efficiency and equity in areas under control of SIDA and AWBs.	Areas previously suffering water shortages now receive adequate supplies.	Annual M&E reports. Supervision missions.	Engineering design ensures equity of supply. No illegal interference by Direct outlets
	Improvement of watercourses within these command areas; hence improved tertiary and on-farm irrigation efficiency, reliability and equity.	Irrigation water supplies equitably distributed at tertiary level. Tertiary O&M costs to farmers reduced.		
	Farmers trained in improved on-farm irrigation practices	Measurable water savings. Increased cropping intensity and yields.		
	Sustainable water user organisations formed and trained at tertiary and secondary level, prepared to accept responsibility for O&M; hence improved prospects for sustainability of physical improvements.	Water user organisations participate in management and share costs of secondary canal operations; also fully manage and finance capital and O&M costs of tertiary systems.		Government commitment to PIM and cost recovery.
	Project impact monitored and analysed to facilitate planning future IIP developments.	Baseline and continuous follow-up survey results available in coherent report form on annual basis		Government commitment to M&E.
	Project implementation capacity of SIDA strengthened for future developments.	Project activities successfully contracted out to private sector.		Government commitment to privatisation of irrigation services.

	Intervention Logic	Objectively Verifiable Indicators	Means of Verification	Assumptions
Activities	Modernization and rehabilitation of main, secondary and tertiary canal systems, provision of water control structures and/or parallel distributary canals for feeding the direct outlets and lift schemes studies, designs, procurement and construction supervision.	**Means:** WB loan for investment costs including costs for infrastructure, vehicles, equipment, technical assistance, and incremental operating costs.	**Base Costs: (US$ million):** Infrastructure modernization Institutional Capacity Building On-Farm Demonstrations M&E; benchmarking and GIS	
Activities	Support to SIDA to enable it to: • carry out public awareness campaign introduce objectives and scope project to farmers. • support the formation and training of tertiary and secondary level water user organisations. • facilitate direct contracting for servic between water groups and private sector.	SIDA/AWB/FO for infrastructure design, public awareness, water user organisation formation and training. for on-farm demonstration programme. M&E and benchmarking programmes. International and local consultants for technical assistance. Local contractors for implementation.	Total (US$ million)	

	Intervention Logic	Objectively Verifiable Indicators	Means of Verification	Assumptions
Activities	On-Farm Water Management Demonstration • participatory demonstrations on about 100 selected farms to improve irrigation practices, water management and crop production • trials of land levelling and other in-field improvements Monitoring and Evaluation • establishment and operation of an M&E programme covering environmental, irrigation and agronomic performance, and hence project impacts.			
Activities	Institutional Support provision of technical assistance, training, logistic support and incremental operating costs to strengthen capacity of SIDA, AWB and FOs and other institutions involved in this and future IDMP developments geared to project management rather than project Implementation (the latter being contracted out to the private sector to the maximum practical extent)			