Pakistan
Irrigation and Drainage: Issues and Options

March 25, 1994

Agriculture Operations Division
Afghanistan, Maldives, Pakistan and Sri Lanka Department
South Asia Region

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CURRENCY EQUIVALENTS
Rupee 1.00 = US$0.033
US$ 1.00 = Rs. 30.0

WEIGHTS AND MEASURES
Metric System
1 Acre = 0.405 ha
1 Acre foot = 1,233.5 cubic meters
1 cubic foot/second (cfs) = 0.0283 cubic meters/sec (m³/sec)

GOVERNMENT FISCAL YEAR
July 1 - June 30

ABBREVIATIONS AND ACRONYMS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ADP</td>
<td>Annual Development Program</td>
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<tr>
<td>AKRSP</td>
<td>Agha Khan Rural Support Program</td>
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<tr>
<td>Bcm</td>
<td>billion cubic meter</td>
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<tr>
<td>CCA</td>
<td>Canal Command Area</td>
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<tr>
<td>CEA</td>
<td>office of the Chief Engineering Advisor to MWP</td>
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<td>CNA</td>
<td>National Water Commission</td>
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<tr>
<td>ERR</td>
<td>Economic Rate of Return</td>
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<tr>
<td>FIO</td>
<td>Farmer Irrigator Organization</td>
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<td>FOs</td>
<td>Farmers Organizations</td>
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<td>FGW</td>
<td>fresh groundwater</td>
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<tr>
<td>FY</td>
<td>fiscal year</td>
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<tr>
<td>FYP</td>
<td>Five Year Plan</td>
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<tr>
<td>GCA</td>
<td>gross commanded area</td>
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<td>GDP</td>
<td>gross domestic product</td>
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<td>GOP</td>
<td>Government of Pakistan</td>
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<tr>
<td>IA</td>
<td>Irrigation Association</td>
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<tr>
<td>IBIS</td>
<td>Indus Basin Irrigation System</td>
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<tr>
<td>ICE</td>
<td>information contracting and enforcement</td>
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<td>ICO</td>
<td>Irrigation Community Organizers</td>
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<tr>
<td>IDC</td>
<td>interest during construction</td>
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<tr>
<td>IDD</td>
<td>Institutional Development Department</td>
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<tr>
<td>I&amp;D</td>
<td>irrigation and drainage</td>
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<td>ID</td>
<td>Institutional Development</td>
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<td>ILC</td>
<td>Irrigation Line of Credit</td>
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<td>IRSA</td>
<td>Indus River System Authority</td>
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<td>ISRP</td>
<td>Irrigation System Rehabilitation</td>
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<tr>
<td>LRMC</td>
<td>long run marginal cost</td>
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<tr>
<td>MAF</td>
<td>million acre feet</td>
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<td>Mha</td>
<td>million hectares</td>
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<tr>
<td>MWP</td>
<td>Ministry of Water and Power</td>
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<td>NCA</td>
<td>National Commission on Agriculture</td>
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<td>NDB</td>
<td>non-development budget</td>
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<td>NGO</td>
<td>non governmental organization</td>
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<td>NIA</td>
<td>National Irrigation Administration</td>
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<tr>
<td>NWFP</td>
<td>North West Frontier Province</td>
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<tr>
<td>OFWM</td>
<td>On-Farm Water Management</td>
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<tr>
<td>O&amp;M</td>
<td>Operation and Maintenance</td>
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<tr>
<td>PID</td>
<td>Provincial Irrigation Department</td>
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<tr>
<td>PRC</td>
<td>Provincial Regulatory Commission</td>
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<td>PRD</td>
<td>Provincial Revenue Department</td>
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<td>PU</td>
<td>public utility</td>
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<tr>
<td>PWA</td>
<td>Provincial Water Authority</td>
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<tr>
<td>RAP</td>
<td>Revised Action Programme for Irrigated Agriculture</td>
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<td>SCARP</td>
<td>Salinity Control and Reclamation Project</td>
</tr>
<tr>
<td>SGW</td>
<td>saline groundwater</td>
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<tr>
<td>SMO</td>
<td>SCARP Monitoring Organization</td>
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<td>STPP</td>
<td>SCARP Transition Pilot Project</td>
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<tr>
<td>SSTP</td>
<td>Second SCARP Transition Project</td>
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<tr>
<td>TA</td>
<td>technical assistance</td>
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<tr>
<td>TW</td>
<td>tubewell</td>
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<tr>
<td>VO</td>
<td>Village Organization</td>
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<tr>
<td>WAPDA</td>
<td>Water and Power Development Authority</td>
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<tr>
<td>WSIPS</td>
<td>Water Sector Investment Planning Study</td>
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<td>WUA</td>
<td>Water Users Association</td>
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GLOSSARY

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
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<tbody>
<tr>
<td>chak</td>
<td>tertiary irrigation command</td>
</tr>
<tr>
<td>kharif</td>
<td>wet season (mid-April to mid-October)</td>
</tr>
<tr>
<td>mogha</td>
<td>outlet from parent (public) supply channel to chak</td>
</tr>
<tr>
<td>rabi</td>
<td>dry season (mid-October to mid-April)</td>
</tr>
<tr>
<td>sarkari khal</td>
<td>communal portion of watercourse</td>
</tr>
<tr>
<td>warabandi</td>
<td>weekly rotational schedule of irrigation deliveries to farmers</td>
</tr>
<tr>
<td>watercourse</td>
<td>irrigation distribution system within a chak</td>
</tr>
</tbody>
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# Pakistan

## Irrigation and Drainage: Issues and Options

### Table of Contents

**EXECUTIVE SUMMARY** ............................................. i

**I. BACKGROUND AND MAJOR PROBLEMS** ............................... 1

  - Major Problems ............................................... 2

**II. DIAGNOSIS** ................................................... 9

  - Market Failures ............................................... 9
  - Government Performance ........................................ 11
  - Investment Planning and Financing Issues ...................... 11
  - Operation and Maintenance (O&M) Issues ....................... 12
  - Other Institutional Issues .................................... 14
  - Technical and Environmental Issues ............................ 15

**III. FROM DIAGNOSIS TO SOLUTION** .................................. 17

  - Options, Choice and Links .................................... 17
  - The Solution ................................................ 18
  - Towards the Long Run ......................................... 20
  - Pricing of Irrigation Water ................................... 23
  - Cost Recovery ................................................ 25
  - Water Markets: Cross-Country Experience ..................... 26

**IV. FARMER ORGANIZATIONS** ....................................... 28

  - Experience in Pakistan ....................................... 28
  - Water User Organizations—Cross-Country Experiences ............. 29
  - Need for Farmer Organizations .................................. 30
  - Promoting Sustainable Farmer Organizations .................... 33

**V. OVERALL INSTITUTIONAL STRUCTURE** ............................. 34

  - Transition Arrangements ....................................... 39

**VI. TOWARDS A STRATEGY** ........................................ 45

  - Overview .................................................. 45
  - Short-term Strategy ........................................... 45
  - Long-term Strategy ............................................ 46
  - Discussions with the Government ................................ 47

Annex I: INVESTMENT OPTIONS IN IRRIGATION AND DRAINAGE SECTOR ......... 48

This report is based on the findings of two missions that visited Pakistan during 1992. Missions members were: Masood Ahmad, Robert Hunt (Joint Task Managers), S. Bell, J. Hentschel, H. Plusquellec (Bank), A. Abidi, P. Harrison, Ed. Stains, and S. Wedderburn (Consultants). R. Faruqee helped with the executive summary and final editing. The Country Director is Mr. Paul Isenman (SA3DR) and the Division Chief is Mr. Ridwan Ali (SA3AG). The green cover draft of the report was discussed extensively with the officials of the Government of Pakistan. The final version of the report takes into account comments and suggestions received from them.

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LIST OF TABLES

Chapter One: BACKGROUND AND MAJOR PROBLEMS
Table 1.1: O&M Funding Requirements (Rs Million) ................................... 7
Table 1.2: O&M Expenditure and Recoveries (Rs Million) ............................... 7

Chapter Five: OVERALL INSTITUTIONAL STRUCTURE
Table 5.1: Transition Phasing ........................................................................... 43

LIST OF BOXES

Chapter One: BACKGROUND AND MAJOR PROBLEMS
Box 1.1: Importance of Irrigation and Drainage ...................................... 1
Box 1.2: Water Resources and Their Various Uses .................................... 3
Box 1.3: Irrigation and Drainage Systems .......................................... 4
Box 1.4: Project Irrigation Delivery Efficiencies ...................................... 5

Chapter Two: DIAGNOSIS
Box 2.1: Canal Water and Drainage - Public or Private Goods in Pakistan? ................... 9
Box 2.2: Operation and Maintenance (O&M) Funding and Cost Recovery .................... 13

Chapter Three: FROM DIAGNOSIS TO SOLUTION
Box 3.1: Dealing with Market Failure in Pakistan’s Irrigation - An Overall Approach ................. 17
Box 3.2: Water Rights - Volume or Share of Flow? ..................................... 20
Box 3.3: Water Rights and Poverty Alleviation ....................................... 21
Box 3.4: Feasibility of Water Markets in Pakistan .................................. 22
Box 3.5: Bank Water Pricing Policy ......................................................... 24

Chapter Four: FARMER ORGANIZATIONS
Box 4.1: Water User Organizations in Philippines .................................... 31
Box 4.2: Transfer of Management of Irrigation Districts to Water Users in Mexico ................. 32

Chapter Five: OVERALL INSTITUTIONAL STRUCTURE
Box 5.1: Incentives for Moving to the New System ..................................... 39

Chapter Six: TOWARDS A STRATEGY
Box 6.1: Monitoring and Control of Groundwater ..................................... 46
Box 6.2: Dissemination Discussion ............................................................. 47

LIST OF FIGURES

Chapter Five: OVERALL INSTITUTIONAL STRUCTURE
Figure 5.1: Proposed Institutional Structure ................................................. 35
EXECUTIVE SUMMARY

(i) Irrigation is central to Pakistan's economy. Around 90 percent of agricultural output (which accounts for more than a quarter of GDP, and more than half of all employment) is entirely dependent on irrigation. Yet Pakistan's irrigation and drainage system is in dire straits. Despite substantial budgetary input, it is facing a shortage of resources and suffering from severe and worsening operational problems. The Government of Pakistan, and the Bank need to work together to devise a strategy to get the irrigation and drainage system out of the present crisis and put it on a sustainable development path.

(ii) The Indus basin irrigation system, the prime source of Pakistan's water resources, comprises the Indus river, its main tributaries, and three major reservoirs (Tarbela, Mangla, and Chasma). River water is diverted by barrages and weirs into main canals and branch channels, distributaries, and minors. Groups of farms are served by watercourses, connected to the system at "outlets" or "moghas".

(iii) The public sector operates the irrigation system above the moghas. Each season, the Water and Power Development Authority (WAPDA) of the Federal Government estimates water availability for the following season. Provincial Irrigation Departments (PIDs) inform WAPDA of provincial water demands at specific locations. WAPDA releases water from reservoirs to meet demands as closely as possible. Limited reservoir capacity of the system does not allow full regulation of rivers for irrigation.

(iv) WAPDA is also responsible for construction and O&M of the big, multi-purpose reservoirs and interprovincial link canals. PIDs are responsible for O&M over the distribution systems above outlets (moghas). O&M of watercourses and field channels are the responsibility of farmers. Off-farm drainage systems are normally developed by WAPDA and handed over to PIDs for operation and maintenance.

The Problems

(v) Pakistan's problems are common to many irrigation systems—waterlogging and salinity, over-exploitation of fresh groundwater, low efficiency in delivery and use, inequitable distribution, unreliable delivery, and insufficient cost recovery.

(vi) The Indus Basin has flat topography, poor natural drainage, porous soils, and a semi-arid climate with high evaporation. In such an environment, irrigation without adequate drainage has inevitably led to rising water tables and eventual salinity. Increases in diversion of river flows, and seepage from canals, watercourses, and irrigated areas have led to a gradual rise in groundwater levels. Presently, about 30 percent of the irrigated area is waterlogged, 13 percent highly waterlogged, while soil salinity is estimated to rob farmers of about 25 percent of potential production of major crops. Drainage thus remains under-developed due to inadequate investments, unsatisfactory management of public expenditure and deteriorating institutional capacity.

(vii) Over the past 20 years, groundwater use has been a major factor in raising agricultural production. Groundwater tubewells not only supply additional water but have provided flexibility to
match surface water supplies with crop water requirements. Because of uncontrolled (and rapid) private-sector development of groundwater (6 percent annual growth), there is a danger of excessive lowering of water tables and intrusion of saline water into fresh-water aquifers.

(viii) Due to age, overuse, and poor maintenance, the efficiency of delivery of the canal system is low, ranging from 35-40 percent from canal head to the root zone. True, Pakistan's efficiency is not particularly low compared to many countries, but some irrigation systems (Gezira in the Sudan, for instance) have efficiency rates of 70 percent. In practical terms, this means that much surface water is currently lost enroute—water that could be profitably used by farmers.

(ix) The Indus irrigation system, which is based on gravity flow, has low use-efficiency. Moreover, it is supply based, and so unable to accommodate changing water demands during the crop season. Inefficient water delivery and water use also mean that, in reality, water does not reach users toward the tail end of the system. In fact, inequity in the distribution of surface water—due to deliveries less than designed levels, poor O&M, and even illegal diversion—is a major concern.

(x) Pakistan's extensive irrigation and drainage systems have been deteriorating because of deferred maintenance and utilization beyond design capacities. Currently, water and drainage charges are not linked to O&M needs. They are, moreover, collected by Provincial Revenue Departments and are deemed to be part of provincial revenues. The gap between O&M expenditures and recoveries through water charges is high (44 percent) and increasing. Although quite favorable compared to many countries, this is poor compared to others such as post-reform Mexico, where the gap is only about 20 percent.

Sources of the Problems

(xi) In Pakistan, as in many other countries, government treats irrigation water as a public good, whereas it is a private tradable good, for which markets can operate (now they operate informally). However, lack of well defined individual property rights and the illegality of sales of surface water severely constrain informal irrigation water markets. Instead of rooting out the barriers to water markets, Government publicly administers irrigation water. Inefficient pricing of water, resource misallocation, rent seeking behavior, and "illegal" trading is the result.

(xii) The Government has not even adequately met the requirements of an administered system. It has failed to make budgetary provisions for operations. Moreover, the public body responsible for irrigation maintenance is separate from (and has poor coordination with) the agency responsible for revenue collection. In the past, administrative discipline was adequate but it has now broken down and the cost of irrigation maintenance has vastly increased. Nor are there any measures available to restore discipline. And even if there were, economic efficiency in irrigation delivery and use cannot be achieved, because the present system cannot offer the right incentives.

(xiii) Unlike on-farm drainage, off-farm drainage is a public good. This is so because, while it may be possible to exclude individuals from direct access to off-farm drains, it is not possible to exclude them from the general area-wide drainage benefit of lowering the water table. Thus, off-farm drainage will have to be supplied by the Government. However, the underlying problem of inappropriate institutional framework will require reforms that will ensure autonomy, transparency, and accountability of present institutional set-up for drainage.
Future Strategy

(xiv) Unless the Pakistan government changes its approach, no future strategy for irrigation and drainage will succeed. Any water service that is not a public good should be commercialized and later privatized. Only with market-determined incentives for irrigation and on-farm drainage is a sustained improvement in performance possible. The government needs to consider taking steps that will remove barriers to a free market in water. Most important, the government will have to draw up enforceable property rights to water, without which any attempt to legalize and commercialize water markets would be futile. Property rights and legalized markets will make the opportunity cost of water transparent, leading to greater efficiency in use.

(xv) The long-term option for the government will be to define individual water property rights, which are necessary to ensure equity in distribution. This would address the problems of tailenders (that is, those at the tail end of the system who receive little or no water), while relieving pressure on ground water resources. As a first step toward individual water rights, Pakistan may like to aim for communal rights, which are legally and administratively easier to establish. User organizations can then translate these communal rights into enforceable individual rights of their members.

(xvi) In establishing water markets, much can be learned from other countries. Successful water markets in, for example Chile, demonstrate not only feasibility but also the substantial gains available.

(xvii) Institutions: The move toward commercial water markets will, of course, require major institutional changes in delivery of irrigation and drainage. Any new set-up should have built-in flexibility. User organizations are insufficiently developed in Pakistan. The best option for the government is to develop user-directed, autonomous, commercially-oriented public utilities (PUs), ensuring operational transparency, and cost recovery of all current O&M and future investment expenditures. Developing PUs on a canal command basis will allow flexibility, a basis for comparison of cost of delivery services, adaption to the local conditions while causing minimum disruption to the overall system. Since users would direct the operational policy of the PUs and only pay for actual deliveries, the utilities would be highly responsive to users’ needs. Because the decentralized utilities would also have a local monopoly on canal-water delivery, there will have to be public oversight on delivery charges and other financial matters to avoid monopoly profits. Public utilities, however, would only be an interim arrangement pending the further development and strengthening of user organizations. Once these organizations are up and running, they will take over management of the system.

(xviii) Farmer organizations (FOs), as the major water users, will be vital to any new market-oriented irrigation system. Their immediate tasks would include organizing farmers to carry out some O&M, ensuring water is distributed in accordance with property rights, monitoring groundwater use, organizing on farm drainage development, and collecting delivery and drainage charges. Such organization would also counterbalance the public utility monopoly and facilitate water trading within (and eventually outside) their areas. At present, trading takes place informally on 70 percent of Pakistan’s watercourses. Farmer organizations would enhance this through facilitation and supervision of trading locally, as well as expanding local markets (particularly to distributaries). Experiences in countries like Mexico, Argentina, Indonesia and the Philippines show that farmer organizations can successfully manage irrigation.

(xix) At the federal level, the best option is to let the Ministry of Water and Power and WAPDA continue in overall charge of irrigation and drainage planning and development, as well as development (and O&M) of inter-provincial canal-water capture, storage and delivery, and flood
protection. Autonomous Provincial Water Authorities (PWA) would be responsible for development (and O&M) of intra-provincial irrigation, drainage and flood protection. O&M and future investment spending of the PWAs and WAPDA would be charged to the public utilities, which would recover them from users through delivery charges and sales of new water.

(XX) Off-farm drainage, a public good, must continue to be the responsibility of the government. However, the public sector institutions in drainage would need to be reconstituted to provide them with the autonomy needed to pursue broad-based investment and cost recovery. Transparency in their operations and accountability for results will be necessary to ensure efficient design and implementation of drainage program. Cost of drainage would be recovered from farmers. Such charges, however, will be collected (along with irrigation water delivery charges) by the canal-command based public utilities on behalf of WAPDA and the PWAs. Tying drainage charges as well as irrigation charges to continued access to irrigation water should greatly enhance drainage cost recovery.

(xxii) Priorities: The strategy for Pakistan’s irrigation and drainage system may have to be implemented in phases. In the short to medium term, priorities are:

- enabling legislation on water rights, quality, markets and institutions;
- pilot projects at canal command level, including setting up public utilities and developing user organizations; and
- organizing and developing Provincial Water Authorities, and strengthening federal water agencies to implement their respective roles in irrigation and drainage.

In the long run, successful pilot projects will need to be extended to the rest of the canal commands, and institutional reform consolidated at the provincial level. It would also be desirable that the relationship between the new provincial authorities and institutions, the utilities, and the farmer organizations become close for a smooth and transparent working relationships and to consult consumers on future development needs. Implementation of the irrigation strategy will take long time. Meanwhile, the Government should continue planning and development of large multi-purpose projects which require considerable lead time and privatization of groundwater development in fresh areas not covered by PUs.

(xxii) The new system of irrigation and drainage (emerging from the implementation of the strategy outlined here) will not only get the system out of the present crisis, it will bring in sustainable benefits to farmers. The new system will guarantee a reliable supply of a minimum amount of water determined as the basic right and offers possibility of acquiring more water through purchases. Most farmer organizations will be able to plan ahead for such purchases and, therefore, availability of water will be known in advance with reasonable certainty. Water charges under the new system are expected to be less than the old system, because part of the O&M will be carried out by the farmers themselves more efficiently than public institutions and PUs will be cost-conscious. The water losses now incurred will be greatly reduced and, so, farmer organizations will have increased supplies of water. In short, the new system will allow farmers to manage their own affairs, adopt a distribution pattern they prefer, and will generate greater farm output and income.
PAKISTAN

IRRIGATION AND DRAINAGE: ISSUES AND OPTIONS

I. BACKGROUND AND MAJOR PROBLEMS

1.1 Agriculture is crucial to Pakistan’s economy, and irrigation is the lifeblood of agriculture. Yet Pakistan’s irrigation and drainage systems are in dire straits because of lack of resources and chronic operational problems.

1.2 The importance to Pakistan of efficient and effective irrigation and drainage can hardly be overstated. Irrigated land supplies more than 90 percent of agricultural production (by value), and agriculture supplies most of the country’s food, accounts for 26 percent of GDP, and employs 54 percent of the labor force. It is also the source of raw materials for major domestic industries, particularly cotton products which account for 80 percent of the value of exports. The health of the agricultural sector also has important implications for poverty relief and private-sector development.

1.3 If irrigation is key to Pakistan’s agriculture sector, an efficient drainage system is essential to sustain irrigated agriculture. Increasing diversion of river flows for irrigation has significantly changed the hydrological balance of irrigated areas in the past century. Seepage from irrigation canals and watercourses, and deep percolation of this water have gradually increased the groundwater table, causing waterlogging and salinity. (Box 1.1).

Box 1.1 Importance of Irrigation and Drainage

1. Pakistan’s climate is arid to semi-arid. Annual rainfall over much of the Indus Plain is uneven and not more than 150mm, while evaporation is high (1,250mm to 2,800mm). This makes non-irrigated agriculture impossible.

2. Pakistan covers about 79.6 million hectares (Mha), roughly 196 million acres. In 1988–89, the cultivated area was 21 Mha (26 percent) of which 16.2 Mha (77 percent) were irrigated. Of the total cultivated area 10.4 Mha were single cropped, about 5.73 Mha were double cropped and about 4.9 Mha were fallow.

3. Irrigation systems were initially developed without provision for drainage. Yet irrigation without adequate drainage in an environment like Indus Basin inevitably leads to rising water tables and salinity. Therefore, adequate drainage is necessary to remove excess water and salts from soils, thus sustaining agricultural production.

1.4 As a critical input to the production process, the irrigation and drainage sector must aim to deliver adequate and timely amounts of water, while evacuating excess. This can be achieved by reducing drought risk, waterlogging and salinity; by increasing crop yields and intensity; and through production of high-value crops. Within this, equity considerations can be addressed by striving to give small farmers

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1. Agricultural imports mainly wheat, sugar, tea, and oilseeds amount to 12-14 percent of all imports, and agriculture inputs, mainly fertilizer, another 3-5 percent of imports.

adequate access to irrigation. The challenge for irrigation authorities is to plan, implement, and operate irrigation and drainage systems to meet these goals in a cost-effective and sustainable manner.

**Major Problems**

1.5 Pakistan has significant natural water resources (Box 1.2), but they are inadequate for crop production on the available land. River flows are highly seasonal. Roughly 85 percent of annual flows are in the Kharif season (summer), and only 15 percent in the Rabi season (winter), but Pakistan does not have enough reservoir capacity in its irrigation systems to store seasonal waters. Moreover, due to inadequate water availability in winter and at the beginning and end of the summer, cropping intensity is exceptionally low. The physical capacity of the irrigation canal system is also a constraint during periods of high demand for crop water. In some areas with underground freshwater, surface supplies can be supplemented by tubewells, but opportunities for further exploiting groundwater are limited.

1.6 In addition to water scarcity, there are other major problems facing the subsector: inefficient management of the surface water system (that is, low delivery efficiency and inequitable distribution, and supply based delivery of water); waterlogging and salinity; over exploitation of groundwater in fresh areas; inadequate operation and maintenance (O&M); and insufficient cost recovery.

1.7 **Low Delivery Efficiency and Inequitable Distribution:** The Indus Basin Irrigation System (IBIS), an extensive network of barrages, canals and watercourses, is the mainstay of irrigated agriculture in Pakistan (Box 1.3). Due to age, overuse and poor maintenance, canal delivery is extremely inefficient. Average delivery efficiency is 35 to 40 percent from the canal head to the root zone, with most losses in watercourses (Box 1.4). The loss of such a major part of surface water not only reduces available water for crops; it also contributes to waterlogging and salinity.

1.8 Some irrigation systems (Gezira in the Sudan, for instance) have efficiency rates twice as high as in Pakistan. However, compared with other countries, Pakistan's delivery efficiency appears quite high. Averages, however, do not reflect the true picture. First they include areas where the groundwater table is high (due to excessive seepage), efficiency is (naturally) high in these areas. Second, farmers in Pakistan do not meet the full requirements of the crops with the available water from the irrigation system. Under such a system, efficiency in field application is higher than a system where the full requirements of the crops are met. Third, Pakistan seems to reuse less irrigation water than many other countries.

1.9 In many irrigation systems with drainage, excess water and that lost in irrigation returns to the river, to be used again downstream. Therefore, while efficiency of any single scheme may be low, efficiency in a river basin can be higher. In Pakistan, return flows are negligible. Reuse is limited to some seepage losses in the areas underlain by fresh groundwater; in saline areas, water is lost permanently. Most importantly, unlike some other countries, where irrigation provides supplemental water, Pakistan's agriculture completely depends on irrigation. In the face of increasing shortages of water in the future, improvement in the irrigation delivery efficiency is a must. At the same time, to avoid problems of waterlogging and salinity and excessive costs of providing drainage, improvements in the irrigation delivery efficiency is extremely essential for Pakistan.

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1. For example, in saline and rice areas on the right bank of lower Indus where groundwater tables are high, the delivery efficiency is relatively higher than other areas.
Box 1.2 Water Resources and Their Various Uses

1 Pakistan is divided into three hydrological regions: the Indus Basin, covering more than 566,000 square kilometers (or 70 percent of the country’s area) and the major source of Pakistan’s water; the Kharan desert in the West Balochistan, with inland drainage; and the arid Makran coast along the Arabian Sea in the Southern part of Balochistan. The deserts in the south (Thar and Cholistan) have no water resources. The flows to the Indus are from glacier and snow melt, as well as rainfall outside the Indus Plain.

### Average Annual Inflows and Water Use in Indus Basin

<table>
<thead>
<tr>
<th>Inflows at Rim stations</th>
<th>Volume Bcm</th>
<th>Share %</th>
</tr>
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<tbody>
<tr>
<td>Western Rivers</td>
<td>161.07</td>
<td>89</td>
</tr>
<tr>
<td>Eastern Rivers</td>
<td>10.02</td>
<td>6</td>
</tr>
<tr>
<td><strong>Tributary Inflows</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Western Rivers</td>
<td>7.73</td>
<td>4</td>
</tr>
<tr>
<td>Eastern Rivers</td>
<td>2.58</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>181.37</td>
<td>100</td>
</tr>
<tr>
<td>Diversions to canals</td>
<td>131.16</td>
<td>72</td>
</tr>
<tr>
<td>Outflow to Sea</td>
<td>39.58</td>
<td>22</td>
</tr>
<tr>
<td>Net System Losses</td>
<td>10.63</td>
<td>6</td>
</tr>
</tbody>
</table>


2 **Water Use in Agriculture**: The Agricultural sector is the major user of water and its consumption will continue to dominate water requirements. Direct rainfall contributes less than 15 percent of the water supplied to crops. The major source of water for irrigation is the Indus Basin Irrigation system (IBIS), to which is diverted 131 Bcm of water annually (at the canal heads); around 48 Bcm or so is pumped from groundwater. Surface irrigation systems are the main source of recharge to the groundwater.

3 **Urban and Rural Sector Water Use**: These use less than 3 percent of average river inflows and about 4 percent of surface water diverted for irrigated agriculture (about 5.3 Bcm) in total. Most urban and rural water is supplied from groundwater except for metropolitan Karachi. In saline groundwater areas, irrigation canals are the main source for domestic water. Over 50 percent of village water supply is through hand pumps installed by private households. Total requirements for urban and rural domestic, commercial, industrial and livestock use are estimated at 12.6 Bcm by the year 2010 and 19.6 Bcm by 2020, that is 10-15 percent of present surface water diversions. Importantly, more than 80 percent of the domestic, municipal, and industrial diversions usually return back to the system, however, with degraded quality. Net consumption here will be about 2.5 Bcm (2 percent) by the year 2010 and 3.9 Bcm (2.9 percent) by 2020.

4 **Hydropower**: Water released by the hydropower plants returns to the river system. The reservoirs are operated under priority to irrigation. Recent increase in thermal generation capacity has reduced the potential conflicts between water releases from reservoirs for hydropower generation and irrigation. Most of the annual storage is required for irrigation, not for hydropower, but conflicts do arise at times.
Box 1.3 Irrigation and Drainage Systems

1 **Characteristics of Irrigation System:** The Indus Basin Irrigation System commands over 14 million hectares and encompasses the Indus River and its major tributaries, three major reservoirs (Tarbela, Mangla and Chasma), 19 barrages or headwork, 12 link canals, 43 canal commands and over 107,000 watercourses. The length of the canals is about 61,000 km with communal watercourses, farm channels, and field ditches covering another 1.6 million km.

2 In the Indus system, river water is diverted by barrages and weirs into main canals and subsequently into branch canals, distributaries and minors. The flow to the farm is delivered by the watercourses which are supplied through outlets (moghas) from the distributaries and minors. The "mogha" is designed to allow a constant discharge that self adjusts to variations in the parent canal. Within the watercourse command (an area ranging from 200 to 700 acres), farmers receive water proportional to their land holding. The entire discharge of the watercourse is given to one farm for a specified period on a seven day rotation. The rotation schedule, called "warabandi," is established by the PIDs if the farmers cannot reach mutual agreement.

3 **Characteristics of Drainage System:** Flat topography and lack of well-defined natural drainage in the Indus Plain create a surface drainage problem which has been compounded by the construction of roads, railways, flood embankments, and irrigation systems that obstruct natural drainage flows. Over the years more than 14,000 kilometers of surface drains have been constructed in Punjab and more recently in tail reaches of Rohri and Nara canal commands in Sindh. The surface and subsurface drainage systems in the irrigated areas of Pakistan are inadequate. Under SCARPs, attempts were made to meet the subsurface drainage needs through deep tubewells. A limited area is provided with tile drainage.

4 **Operation and Maintenance:** Each season, WAPDA makes an estimate of water availability for the following season and the Directorates of Regulation of PIDs are consulted for anticipated surface water requirements. During the season, the PIDs communicate their water demand (called water indent) to WAPDA at specific points in the system at 10-day intervals. WAPDA then releases water from the reservoirs to meet the provincial demands as closely as possible. As the season progresses, adjustments are made to reflect the actual inflows to the system. Essentially, all of the available water is divided among their canal commands by PIDs, based on the capacity of individual canals and internal policies of use of reservoir storage between rabi and kharif seasons. The allocation and distribution of water within the canal command is the responsibility of the PIDs and is controlled by the pattern of supply at the head of the canal. The main objective of distribution within the canal command is to supply throughout equitably.

5 WAPDA is responsible for the operation and maintenance (O&M) of large multipurpose reservoirs and interprovincial link canals. O&M of the distribution system above the mogha is the responsibility of the Provincial Irrigation Departments (PIDs), and farmers are responsible for O&M of watercourses and field channels. The Government has full responsibility for providing drainage. Drainage systems are usually developed by WAPDA and they are handed over to the PIDs for O&M. The O&M expenditure is collected by levying water charges and/or drainage cess. In Punjab and North West Frontier Providence, water charges are assessed by the PIDs, and, in Sindh and Balochistan by the Provincial Revenue Departments (PRDs). PRDs are responsible for collection of water charges in all provinces.

6 **System Performance:** The irrigation system is performing poorly, delivering only 35-40 percent of the water from the canal head to the root zone. Only a part of total losses contributing to groundwater recharge in fresh areas are recovered through tubewell pumpage. Water distribution, contrary to the system’s objective, is not equitable. Significant areas lack drainage and excessive seepage results in waterlogging and salination.

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1. About 18 billion m³ of live storage.
Box 1.4 Project Irrigation Delivery Efficiencies.

Project efficiencies is defined as overall efficiency of water use of an individual project. It includes operation, conveyance, distribution and field losses. It varies significantly from project to project and depends largely on the type of irrigation facilities and characteristics of the area. For comparison with the Pakistan canal commands, delivery efficiency to the root zone of a few gravity flow irrigation schemes is given below:

<table>
<thead>
<tr>
<th>Country</th>
<th>Scheme</th>
<th>Overall Irrigation Efficiency (Percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pakistan</td>
<td></td>
<td>35-40 a/</td>
</tr>
<tr>
<td>Colombia</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>India</td>
<td>Behbahan</td>
<td>20-30</td>
</tr>
<tr>
<td></td>
<td>Moghan</td>
<td>same</td>
</tr>
<tr>
<td></td>
<td>Khuzestan</td>
<td>same</td>
</tr>
<tr>
<td>Iran</td>
<td>Sinaloa</td>
<td>37</td>
</tr>
<tr>
<td>Mexico</td>
<td>Panuco</td>
<td>26</td>
</tr>
<tr>
<td>Morocco</td>
<td>Doukkala Gravity</td>
<td>42</td>
</tr>
<tr>
<td>Philippines</td>
<td>Upper Pampanga</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>Aurora Penaranda</td>
<td>36</td>
</tr>
<tr>
<td>Sudan</td>
<td>Gezira</td>
<td>70</td>
</tr>
<tr>
<td>Thailand</td>
<td>Lam Pao I</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>Lam Pao II</td>
<td>28</td>
</tr>
<tr>
<td>USA</td>
<td>Unlined canals with furrows or corrugations on farms</td>
<td>33-50</td>
</tr>
</tbody>
</table>

a/ Delivery efficiency is higher in areas with extremely high water tables, also, due to deliberate under-irrigation, field application efficiency is higher than for irrigation systems designed to supply full crop water requirements. As a result the overall average for the canal command area is higher than might be expected and distorts the true picture in many localities.


1.10 There is another serious problem of the irrigation system: inequitable distribution. Optimistic assumption in the original design about delivery efficiency means that in reality water does not reach users at the tail end of the system—or, at least not at the rate intended in the design. Illegal pumping from canals, moreover, adds to the inequity in distribution.

1.11 Supply Based System: Canal systems were originally designed as run-of-the-river to maximize cropped area, with minimum water consumption, and simple operation and administration. Canals were intended to provide "equitable" distribution, with no interference by the canal establishment. Although the development of barrages, reservoirs, and link canals have provided more control over distribution,
the system is operated on historic canal diversion patterns. Thus, in many canal systems, there is a mismatch of water supplies to crop water requirements at the farm level, a mismatch which hurts agricultural production.

1.12 *Waterlogging and Salinity:* Any irrigation without adequate drainage in an environment like the Indus Basin (flat topography, poor natural drainage, porous soils, semi-arid climate with high evaporation) will inevitably lead to rising water tables and salinity. Increase in the diversion of river flows for irrigation, seepage from canals, watercourses, and irrigated areas have meant a gradual rise of the groundwater table. By the 1960s, a series of salinity control and reclamation projects (SCARP) were initiated. Despite these efforts, about 30 percent of the gross commanded area (GCA) is waterlogged and about 13 percent is considered highly waterlogged.

1.13 Even if irrigation water is relatively free of salts, repeated irrigation and the rise in the water table will dissolve salts in the soil and bring them towards the surface. It is estimated that about 8 percent of the gross commanded area is severely salt-affected and another 6 percent is moderately affected.¹ Soil salinity may be "robbing" Pakistan of about 25 percent of its potential production of major crops.²

1.14 *Over Exploitation of Groundwater in Fresh Areas:* Groundwater use has been a major factor in raising agricultural production over the past 20 years. Groundwater tubewells not only supply additional water, but provide flexibility to match surface water supplies with crop water requirements. Due to explosive development of groundwater by the private sector (roughly 6 percent annual growth), there is danger of excessive lowering of water tables and intrusion of saline water into fresh water aquifers. Furthermore, in many canal commanded areas (CCA), where canal water is not sufficient because of inequitable distribution, farmers depend on tubewells and tend to overexploit groundwater. Excessive pumpage, in the absence of adequate leaching and ineffective conjunctive use of surface and groundwater, caused salinity in the root zone.

1.15 *Inadequate Operation and Maintenance:* Pakistan's irrigation and drainage systems have been deteriorating, because of deferred maintenance and utilization beyond design capacities. In 1983 the Government embarked on the first Irrigation Systems Rehabilitation Project (ISRP-I), under which all provinces increased O&M funding by more than 15 percent a year. Under the (second) ISRP-II, O&M funding levels for FY88 for surface irrigation and sub-surface saline facilities were considered adequate and spending on O&M of public groundwater tubewells were excluded on the assumption that they will be privatized. Provinces agreed to maintain the FY88 levels of expenditure on surface irrigation, and sub-surface saline drainage facilities in real terms. However, actual expenditure has fallen far short of FY88 levels in all priorities except the North West Frontier Province (NWFP) (Table 1.1). The overall gap is more than 24 percent, but is as high as 37 percent in Sindh. Moreover privatization of groundwater tubewells is slower than planned, and in Punjab and Sindh (where most of these tubewells are located), O&M requirements are twice as high as estimated. Thus, the financing gap would have been even larger, if O&M requirements of public-owned tubewells had been included.

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¹ Soil Salinity Survey by WAPDA, 1981
Table 1.1 O&M Funding Requirements (Rs Million).

<table>
<thead>
<tr>
<th></th>
<th>FY88</th>
<th>FY89</th>
<th>FY90</th>
<th>FY91</th>
<th>FY92</th>
</tr>
</thead>
<tbody>
<tr>
<td>Requirements¹</td>
<td>1,703.9</td>
<td>1,874.9</td>
<td>2,160.6</td>
<td>2,408.3</td>
<td>2,619.9</td>
</tr>
<tr>
<td>Expenditure¹</td>
<td>1,703.9</td>
<td>1,512.8</td>
<td>1,616.5</td>
<td>1,707.8</td>
<td>1,985.4</td>
</tr>
<tr>
<td>Shortfall (percent)</td>
<td>0.0</td>
<td>-19.3</td>
<td>-25.2</td>
<td>-29.1</td>
<td>-24.2</td>
</tr>
</tbody>
</table>

¹ Includes O&M expenditure on surface irrigation and sub-surface saline drainage facilities and excluding public tubewells in fresh groundwater tubewells and surface drains. Requirements are based on targets agreed with the Bank under ISRP-II project.

Sources: Provincial Plans for Annual Operation and Maintenance. Provincial Irrigation Departments, and Ministry of Water and Power.

1.16 Insufficient Recovery of O&M Expenditure: In the not too distant past, capital costs of irrigation development were recovered from users. In recent years, however, water and drainage charges were intended to cover only O&M. In fact, charges are not linked to O&M needs; they are collected by the Provincial Revenue Departments and become part of provincial revenue. The gap between O&M expenditure and recoveries through water charges has been increasing—reaching 44.4 percent in FY92 (see Table 1.2). In Punjab and Sindh provinces, the gap is about 30 percent. In the NWFP and Balochistan the gap is as high as 80 percent. The gap between O&M requirements and recoveries in Punjab and Sindh would rise to more than 60 percent, if expenditure of government tubewells were also included. The overall gap of 44 percent increases to 57 percent if recoveries are compared with O&M requirements instead of expenditure.

Table 1.2 O&M Expenditure and Recoveries (Rs Million).

<table>
<thead>
<tr>
<th></th>
<th>FY88</th>
<th>FY89</th>
<th>FY90</th>
<th>FY91</th>
<th>FY92</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expenditure¹</td>
<td>1,703.9</td>
<td>1,512.8</td>
<td>1,616.5</td>
<td>1,707.8</td>
<td>1,985.4</td>
</tr>
<tr>
<td>Recoveries</td>
<td>987.1</td>
<td>1027.7</td>
<td>962.2</td>
<td>1196.6</td>
<td>1104.5</td>
</tr>
<tr>
<td>Shortfall (percent)</td>
<td>-42.1</td>
<td>-32.1</td>
<td>-40.5</td>
<td>-29.9</td>
<td>-44.4</td>
</tr>
</tbody>
</table>

¹ Includes O&M expenditure on surface irrigation and sub-surface saline drainage facilities and excluding public tubewells in fresh groundwater tubewells and surface drains. Requirements are based on targets agreed with the Bank under ISRP-II project.

Sources: Provincial Plans for Annual Operation and Maintenance. Provincial Irrigation Departments, and Ministry of Water and Power.

1.17 Pakistan's recovery of O&M spending is poorer than a few countries. Iran for example recovers 60 to 70 percent and the recovery rate in Mexico after the reform has reached about 80 percent. Pakistan's record, however, appears better than many other countries. In India for instance, O&M recovery is only about 7.5 percent, in Bangladesh it is 10 to 15 percent, and in Indonesia, 8 to 10 percent.
The true picture is not that favorable, given the low requirement of Pakistan's irrigation systems. The systems were designed to cover a large area, providing some water (less than required) to many users with very little interference by the operational staff. The required O&M spending, especially in Punjab and Sindh, is very low. Including public groundwater tubewells, it is about US$11.0 per hectare; excluding tubewells, requirements are halved. For comparison, O&M requirements in the Yaqui irrigation district of Mexico are US$60.00 per hectare.

1.18 The sources of these problems are discussed in the following chapter. Chapter III discusses options and potential solutions to these problems. Privatizing the irrigation and drainage systems is discussed in chapter IV. Chapter V takes a look at an overall institutional structure. Chapter VI concludes with a recommended strategy.
II. DIAGNOSIS

2.1 Waterlogging and salinity, over-exploitation of fresh groundwater, low efficiency in delivery and use, inequitable distribution, unreliable delivery, and insufficient cost recovery are not the causes but the symptoms of a deeper problem. The real problem is that the Government has treated irrigation water as a public good, when it is in fact a private good (Box 2.1). The Government has continued with this approach instead of directly addressing longstanding roots of the technical deficiencies and the failures of markets and administration that has allowed the deficiencies to grow. The problems have been compounded by inadequate public-sector investment in drainage, unsatisfactory management of public expenditure, deteriorating institutional capability and an inability to respond to these concerns.

Box 2.1 Canal Water and Drainage - Public or Private Goods in Pakistan?

The key defining characteristics of a public good are "nonsubtractability" (or "nonrival consumption" --the ability to consume as much of a good as desired with no reduction in the amount available to others) and "nonexcludability" (the inability to exclude specific individuals - e.g. users who fail to pay a share of the costs - from consuming a good, e.g. street-lighting). The first clearly does not apply to canal water, while the second is now present only as result of a decline in authority of the irrigation agencies (PIDs). Because canal water consumed by a farmer's crops is not available to for the crops of another farmer and access by farmers to canal water can be restricted, canal water can be bought and sold like any other private good. Pakistan's informal water markets are clear evidence of this.

By contrast, off-farm drainage is a public good. Both "nonexcludability" and "nonsubtractability" are at least partially present. In drainage, while farmers who don't pay their share of costs may be excluded from direct access to drains, they cannot be excluded from the general area-wide benefit of lowering the water table. Where capacity utilization is less than full, which it generally is, nonsubtractability is present.

Market Failures

2.2 Market failures arise from extranalities--mainly due to the private cost being less than the social cost for many competing water uses, the absence (or non-enforcement) of water rights, and scale effects from the natural monopoly of large-scale storage and distribution schemes. The problem is that the Government has interpreted these as arising from irrigation water as a public good, rather than addressing these problems directly and allowing (regulated) market forces to determine operations. This interpretation is reinforced because the institutional structure and financing for irrigation are public, so governments view irrigation as a public good. The "nonrival consumption" element of a true public good, however, clearly does not apply to canal water. While "nonexcludability," the other major public good characteristic, is claimed for canal water, this is a result of a decline in the autonomy of the irrigation authority. True, the highest tiers of the irrigation system (such as multi-purpose reservoirs, and inter-river transfer facilities) have the characteristics of a natural monopoly requiring public regulation--but not so with irrigation water.

2.3 Treating irrigation water as a public good inhibits much needed institutional reform, and the creation of independent and (eventually) private irrigation agencies. Policy makers and planners are invited to continually call for better performance by public-sector irrigation institutions, despite the absence of institutional autonomy and adequate financial incentives for personnel. The situation is well summarized by Repetto: "For the most part, management problems are symptomatic of the underlying conflicts in the political economy of public irrigation. But, many of the remedial projects deal mostly with the symptoms and not the underlying conflicts. If performance in public irrigation is treated either as a mechanical or design problem, or as a management problem, and the more fundamental difficulties of the political economy of public irrigation are not resolved, efforts to improve performance will probably have limited success."

2.4 Treating irrigation water as a public good results in underpricing of water, sending wrong signals to system operators and users. The publicly-administered water-market cannot price the water efficiently, as a bureaucracy simply cannot substitute for a market. This causes resource misallocation, rent-seeking behavior and informal trading (illegal), reflecting efforts by operators and users to bring about a balance between supply and demand for the water. Administrative and budgetary independence between the system’s operating and revenue generating functions exacerbates the problem. To resolve these problems, the roles of government and the private sector in the irrigation system need to be redefined.

2.5 Off-farm drainage is correctly treated as a public good to be supplied by government. Because the beneficiaries cannot be excluded, they have little incentive to pay for the use of a drain, and the incentive for nongovernment entities to invest in providing the service is negligible. Also, because the marginal user creates little additional cost, administered efficiency pricing is infeasible. Where drainage benefits to the economy outweigh their costs, government can provide the service and recover the cost through a charge, direct or linked to irrigation water. In Pakistan, the Government has not been recovering drainage cost from the beneficiaries and hence expenditures on drainage has been inadequate. Waterlogging and salinity are serious drainage problems and an increasing burden on sector productivity. Tubewell development has moderated the problem in areas of fresh groundwater (FGW); but, in areas of saline groundwater (SGW), greatly expanded government investment is needed. But the inadequacy of investments is not the only problem. The lack of autonomy in detailed programming and implementation, and often inappropriate constraints of regular civil service regulations make program management difficult. Corrective restructuring to provide necessary autonomy to any future drainage implementation agency must also provide for full accountability and transparency of the agency’s work program.

2.6 To restore financial and physical sustainability and also efficiency to the irrigation system, hidden gains or rents need to be made clear and tradable; there needs to be a direct connection between water charges and deliveries. This connection used to be accomplished through government maintaining adequate (and collect almost all) O&M charges, coupled with a rigorous enforcement to protect the physical infrastructure and ensure delivery of individual water allocations. Up to the mid 1970s, the system made a net contribution over O&M costs to provincial treasuries (Box 2.2). In principle it is possible to restore the current deficit to a surplus; but, in practice, this would require enormously unpopular disciplinary actions, possibly causing severe political repercussion if directly attributable to a government ministry. A different solution is needed.

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Government Performance

2.7 Implementation and operation of a large scale integrated irrigation and drainage system in Pakistan's developing economy required substantial government financing at the outset. But today, continued direct public-sector administration is no longer necessary. In fact, due to administrative, institutional, and technical problems, declining performance by civil service administrators has become the underlying cause of deterioration in the whole systems.

Investment Planning and Financing Issues

2.8 Investment Planning: In irrigation and drainage, investment planning is conducted on three levels. Sectoral plans establish a medium- to long-term framework for sectoral development; five-year plans are for the short-term; and, yearly allocations are made by the Annual Development Program (ADP).

2.9 In the past, much effort has been applied to sectoral planning. Plans, such as the Revised Action Program (RAP) and Water Sector Investment Planning Study (WSIPS), are prepared with foreign assistance and take a comprehensive look at sectoral requirements and objectives. But even if accepted by the Government, the sectoral plans are rarely incorporated wholly, into either five-year plans or the ADP. The general tendency is to invest in poorly planned civil-works packages. Institutional and policy recommendations are often ignored.

2.10 The ADP follows a lengthy and complex process. Its proposals pass through various federal and provincial departments and committees and planning is based on financial limits set each year by the Federal Government. The overriding concern during ADP preparation is the allocation of provincial and sectoral shares—not the aims and performance of projects. Because the size of the ADP is determined after deducting nondevelopment expenditure, investments are mainly driven from the supply side, with little regard for implementation requirements and sectoral priorities.

2.11 Project Preparation and Ranking: There is no identifiable and rational process for identifying and prioritizing investments. Project approval follows guidelines issued by the Planning Commission in the 1960's, and originally intended as a project profile but now substituting for a feasibility report. It generally does not have details required for successful project implementation. Project approval is lengthy and, often, the main concerns are affordability and social benefits, rather than economic criteria. Projects are approved as they are proposed, which allows for politicalization of selection. There is no process for evaluating and ranking potential projects. A project is unlikely to be approved, even if economically viable, if it is not included in the current five-year plan. On the other hand, project approval does not guarantee funding.

2.12 Provincial and federal agencies are inadequate for effective project preparation. Cost estimates are distorted by out-of-date rate schedules; designs are prepared using outdated techniques and guidelines; projects are prepared without considering inter-project and inter-sectoral linkages. Due to these shortcomings, feasibility plans for externally assisted projects are usually prepared by consulting firms, and increasingly they are helping the agencies in planning and development because it is becoming difficult for government agencies to retain qualified staff. At present, however, there are only a few qualified domestic firms; development of others is constrained by ambiguous regulations and unfair hiring practices. Moreover, hiring consulting services is lengthy and complex, often taking years.
2.13 These shortcomings are, perhaps, among the major constraints affecting performance during the Seventh Plan, and are summarized in the Water Sector working paper for the Eighth Plan preparation:

"By and large each project is revised time and again in terms of cost, schedule, and benefits which disturb(s) the investment plan and adversely affect(s) policies and targets. There is an imperative need for proper planning, project preparation, estimating costs and monitoring during implementation for each water development and drainage project. Continuous monitoring and periodic reviews are necessary for corrective action to complete the project within the envisaged time and cost."¹

2.14 Investment Financing and Recovery: Pakistan's irrigation and drainage has been almost entirely funded by the public sector. Given the political climate and the state of the banking system, the costs of establishing the infrastructure to achieve economies of scale could not have been met by the private sector. However, subsequent tubewell irrigation investment² involved substantial private-sector investment, an indication of the ability and willingness of the private sector to finance further development.

2.15 Since the mid-1980's, public spending on irrigation has been declining by about 4 percent a year in real terms. Completion of projects underway have been delayed. There is a tendency, also, to start new projects without ensuring the availability of funds, further delaying completion. Funds available for project implementation are reduced severely due to high interest during construction (IDC) charged to the project because of the prolonged implementation period. One major reason for the shortage of development funds is the failure to recover capital costs from users directly. In the past, some capital costs were recovered under provisions of the Canal and Drainage Act. Land previously classified as waste (uncultivated), upon irrigation development was sold to farmers. Land which was farmed (owned privately) upon irrigation from a public system is also subject to "betterment charges."³ Water charges, too, had a component for capital-cost recovery.⁴ Over the years, however, capital-cost recovery has lapsed and water charges now tend to be equated only to recovery of O&M costs. The only exception is the On-Farm Water Management program, where about 30 percent of the cost of some materials is recovered.

Operation and Maintenance (O&M) Issues

2.16 O&M Financing and Cost Recovery: Inadequate O&M is largely the result of inadequate institutional capability and lack of funding. PID's, operating under a structure and rules formulated over 100 years ago, resist any form of institutional changes, modern technology and management practices. Emphasis on technical performance is declining, along with PID's ability to enforce statutory provisions of the Canal and Drainage Act, which were the foundations of good irrigation practice.

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2. Made possible in its current extent in the IBIS area by canal-water seepage only, and virtually entirely dependent on continuation of seepage for recharge.
4. Revenue receipts were higher than the total O&M expenditure by 13 and 25 percent in 1972-73 and 1973-74 respectively. In 1974-75, for the first time the revenue receipts fell below the O&M expenditure by 18 percent.
2.17 Funds allocated to PIDs by provincial governments are insufficient for proper O&M (Table 1.1). The shortfall stems from low water rates, and inadequate assessment and collection of charges. Water charges in Pakistan apply only to surface-water supply, and are imposed on an acreage basis. Moreover, changes vary according to the crops grown and rates are set significantly below those levels needed to recover O&M expenditures. (Water charges are only 5 percent of the total agricultural input and about 5 percent of the net farm income.) On top of that, revenue collection and implementation of O&M is undertaken by different agencies. Revenue does not go directly to PIDs, which eliminates incentives to improve water delivery and the collection of charges (Box 2.2).

### Box 2.2: Operation and Maintenance (O&M) Funding and Cost Recovery

1. **O&M Funding.** The O&M of reservoirs and inter-river link canals is managed by the Water and Power Development Authority (WAPDA), on behalf of the federal government. The O&M of the irrigation canal systems down to the watercourse outlets (or mogha) is the responsibility of the Provincial Irrigation Departments (PIDs). Beyond the mogha, farmers maintain the watercourses and farm channels. The maintenance of SCARP tubewells and tile drainage pumps is also the responsibility of PIDs. Funding for irrigation O&M, including the SCARP tubewells, is allocated to PIDs by the Provincial Finance Departments through the Non-Development Budget. Normally O&M funding in the NDB should be met by financial resources generated within the Province. O&M funding, however, has been adversely affected by the current public finance constraints, even though the government has given supplemental grants to provincial NDBs. Government has assumed the responsibility for rehabilitation of flood protection works and included it in the Federal Annual Development Program (ADP).

2. In the 1970s, most of the O&M budget was absorbed by SCARP tubewells, resulting in shortfalls to meet needs for canals, surface drains and flood protection works. Funding was increased by about 15 percent a year in FY83 through FY87, and they generally met or exceeded the agreed O&M targets established under Irrigation Systems Rehabilitation-I project. Funding in FY93 is estimated to fall short by about 5 percent in Punjab, 31 percent in Sindh, and 33 percent in Balochistan.

3. **Cost Recovery.** To provide adequate funds for proper maintenance, it is the Government's objective to recover, at a minimum, the entire O&M expenditure through water charges. In Punjab and NWFP, water charges are assessed by PIDs, and in Sindh and Balochistan by the Revenue Department. In all provinces, collection is by the Revenue Departments. Water charges are based on crop acreage and the type of crop (indirectly relating to volume of water use).

4. A major reason for the inadequacy of O&M funds is the low level of water charges. Until the early 1970s, revenue receipts from water charges were higher than O&M costs. During the mid-seventies water charges only covered about 70 percent of O&M expenditures. However, O&M spending increased rapidly due to the increase in cost of operating SCARP tubewells. Through FY79-82, all provinces increased water charges by about 95 percent, but they were still inadequate to recover full O&M cost. Sindh and Balochistan further increased water charges in FY83, and Sindh introduced a new drainage cess in FY84. Since FY84, water charges have not been raised by provinces, except Balochistan. Present recovery is less than 30 percent of all O&M expenditure (including SCARP Tubewells in fresh areas). In the drainage sector the recovery is less than 20 percent.

2.18 In Pakistan, irrigation water prices are simply the O&M costs collected. Yet, based on actual prices paid in Pakistan by farmers in private sales, the value of the water to users is as much as ten times higher than current (official) charges. The big differences between the cost and the value of water is a

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hidden gain, or rent--the source of much of the break-down in discipline. This, in turn, leads to breakdown in system-discipline and unequal distribution, as users struggle to capture this rent through distorting public distribution (illegal pumping, or breaking the mogha or the warabandi).

2.19 Farmers are quite willing to make informal payments directly to irrigation-system officials to obtain additional water. Yet, they are unwilling to pay even the current low O&M charges, because these are seen as unrelated to any water deliveries or O&M services they may get from the Provincial Irrigation Departments (PIDs). At the same time, the PIDs budgets are unrelated to water charges, making them independent of (and indifferent to) user requirements, although they may be responsive to individual users as part of rent seeking.

2.20 **Equity in Water Distribution:** There is inequity in distribution at all levels of the systems. Within a watercourse command, water delivered to the farmers at the head of the system is generally more than to the farmers at the tail. Similarly, outlets on a minor (or distributary) receive differing amounts of water. Inequity within a watercourse command occurs because of excessive losses (seepage, dead storage and leakages) and illegal diversion. Poorly maintained watercourses have the greatest losses and highest illegal diversions. In the warabandi system, losses in the watercourses are not sufficiently accounted for. Fairness and equity in distribution can only be obtained by incorporating actual watercourse losses in the warabandi.

**Other Institutional Issues**

2.21 **Contracting and Construction Industry:** The monitoring and evaluation of project implementation and capabilities for construction management requires strengthening. Recent irrigation and drainage projects have been plagued by implementation problems associated with inefficient operation and management of private contractors. On the other hand, large contracts for construction of link canals, barrages, and dams under the Indus Basin Project were completed on time and often within estimated costs. Overall performance, however, is poor. Good local contractors are rarely attracted to irrigation works, preferring more profitable building construction. Irrigation contractors are mostly small, and lack good equipment and management. Large projects are usually foreign financed, and most of the local contractors do not meet the criteria for international competitive bidding. Improving the irrigation construction industry is essential. There is plenty to improve. Employers treat contractors as adversaries instead of partners in project development. There is preferential use of public companies and departmental work forces, inequitable contracting practices, underdeveloped business environment and institutions, and lack of resource management and joint venture formation.

2.22 **Inter-agency Coordination:** Inter-agency coordination between the agriculture and irrigation agencies, which is crucial for efficient use of water, is almost nonexistent. Studies in the late 1970s found inadequate agency coordination and noninvolvement of beneficiaries as one of the major constraints to agricultural production. The RAP and the National Commission on Agriculture (NCA) recommended that the first step needed was the consolidation of the irrigation and agricultural agencies. Little

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1. In designing the canal systems the assumed watercourse losses ranged from 10-15 percent, actually they are higher.


progress, however, has been made towards implementing recommendations dealing with such basic institutional changes.

2.23 The WSIPS recommended an independent commission to review irrigation and drainage institutions, particularly their responsibilities, performance, coordination mechanism, problems, and constraints. From discussions of the Eighth Five Year Plan it appears that the Government realizes the urgency of tackling the administratively and politically difficult problem of inter-agency coordination.

Technical and Environmental Issues

2.24 System Design: Pakistan's irrigation system was designed to distribute water with minimum human interference, and low operation costs without rapid communications. There are few structures to regulate canal flow and the outlets run whenever a distributary or minor is running; no escapes are provided at the tail of the system and the surplus flows have to be absorbed within the command. The canals are unlined, designed to remain in equilibrium under varying sediment loads. These features add to inflexibility of operations. They were suitable for the low cropping intensity originally intended, but are now constraints on water management to maximize crop production. Apart from the size of the investments required, there are, however, constraints on remodelling and improving the canals--for example, major canals cannot be shut down for long periods and there are difficulties in construction and operation of parallel canals.

2.25 Each watercourse is a miniature irrigation system, with channels up to 10 miles long. Watercourse commands are areas ranging from 200 to 700 acres with a discharge of one to three cusecs. Each command is divided into 25 acre squares. Each square has access to the public watercourse at a single point and a network of farm channels. The average farm size is much smaller than the square. Farms are usually fragmented, and parts are not cropped each season. As a result, channels can take up to 8 percent of the square’s area. A better organized square would allow for more cropping area and less water loss. Improved layouts of farm land with short and fewer farm channels could also improve the on-farm delivery efficiency. Redesign of farm layout would require land consolidation/integration, which is difficult in Pakistan because of poor land records. Even so, these designs could easily be adopted in new areas. Reducing the length of public watercourses offers further potential for water savings. This would mean increasing the number of minors, an option only possible where farmers take over the responsibility of O&M of minors and distributaries.

2.26 Drainage Technology: Although Pakistan has considerable experience in drainage, there still is no agreement on what is the best technology, particularly for achieving a desirable salt balance in the root zone. In the past, deep tubewells, tile drains, interceptor drains and surface drains have been installed in different parts of the country. Each technology has advantages and disadvantages. Some drainage problems can be avoided through reallocation of surface water and water conservation. But the best solution for a particular area depends mainly on local conditions. In Pakistan, there are no guidelines on the design of a drainage system, determining the optimal combination of water allocation, water conservation, and use of specific drainage technology to address the drainage problems. Given the size of the problem (in area coverage and cost), it is important that a balanced approach be adopted.

2.27 Municipal and Industrial Pollution: Harmful pollutants end up in irrigation (and drinking) water downstream from urban areas and plants. Urban centers contain more than 33 million people in Pakistan’s four provinces. Only 25 percent have flush sanitation. Sewage and other waste waters collected are mostly discharged, untreated, into drainage and river systems. There are no controls on the discharge of the industrial waste water effluent either. It is estimated that only 3 percent of the
industries currently treat their effluent to international standards. In Punjab, the chemical industries, tanneries, textile plants, steel mills, and other factories located at Kala Shah Kaku, discharge effluent containing hydrochloric acid and high levels of organic matter directly into the Deg Nallah, a tributary of the Chenab River. The Pakistan Environmental Protection Agency was created in 1983, but remains a fledgling organization.

2.28 **Delta Ecology:** The Water Apportionment Accord recognized the need for minimum escapages to sea (below the Kotri barrage), to check seawater intrusion up the Indus River, and reduce environmental degradation. To estimate the available water for irrigation use upstream, it is critical to ascertain both the quantity and the timing of the water to be released into the delta system. It is also crucial for reaching a decision on the viability of additional storage in the system. The Accord says that the optimum flow below the Kotri is 10 Maf annually. The draft Eighth Five Year plan also takes this figure for determining water availability. The same figure can be used in estimating the available water for future development at least until the Indus River Authority gives a final decision on minimum flow.  

2.29 **Management Information Systems:** Water is the constraint on agricultural production in Pakistan; therefore, appropriate accounting of water is fundamental to investment planning and efficient resource use. Discharge data of rivers and tributaries are inconsistent and out of date. Records of water diversions to the distributaries/minors and outlets are either not kept or inaccessible. Similarly, the groundwater monitoring data and information is not cataloged systematically and is recorded on paper, which is not very accessible.

2.30 **Use of simulation and optimization models to assist in systems operations (reservoir, canals, distributaries, and minors) of complex irrigation system is essential.** Computerized databases for land records, and cropped area could assist in advance cropping planning, water demand forecast, revenue collection, and maintenance of canals.

1. A technical study will be carried out to assist the GOP in deciding minimum desirable flow below Kotri Barrage.
III. FROM DIAGNOSIS TO SOLUTION

Options, Choice and Links

3.1 There is no direct commercial relationship between irrigation water suppliers and users, and no management autonomy in irrigation agencies. Both are major factors in the breakdown of administrative, nonmarket, discipline. Options to address the problem are: (a) direct legal intervention to restore discipline, by exhortation and coercion; (b) revival of the existing agency through reorganization and realignment of staff and responsibilities; (c) turn the system over to user groups; (d) restructure the agency as an autonomous public utility, with a hard budget constraint and a mandate of self-sustainability; or (e) privatization.

3.2 Pakistan's choice is clear. It should seek to commercialize any service or product which is not a public good (Box 3.1). Irrigation is not a public good and so should be commercialized. In this way, market incentives can promote improvements in efficiency. Within IBIS, a series of autonomous public utilities, independent of the regular civil service, are an absolute must.¹ Since the utilities will be publicly owned, this approach can only be as successful as the government's commitment to their independence and commercialism. Complete privatization is preferable in the long-run, as it removes any doubts about independence and commercialism and clearly resolve property rights issues. But, Pakistan's irrigation system is unlikely to be ready for such an institutional turn-around in the foreseeable future.

Box 3.1 Dealing with Market Failure in Pakistan's Irrigation - An Overall Approach

A new institutional approach is needed to correct financial imbalances and restore user discipline and system efficiency. A clear understanding of the basic problems here (private versus public goods, the sources of externalities and market imperfections) is essential to dealing with these. For efficiency, to the maximum extent possible private goods should be supplied by the private sector. Externalities require identifying the sources and developing structures to admit corrective market incentives and discipline. Market imperfections require independent regulation of the market. Direct commercial links between suppliers and users of canal water must be established. The need for competition between institutions should guide overall design of the new institutional structure. Inevitable monopolies must have countervailing groups in their marketplaces, as well as being overseen by independent regulatory agencies. Self-sustainability (based on autonomy and commercial objectives) and public accountability (based on transparency in operation) must be explicitly included in individual institutional design at all levels. Flexibility in detailed design options is important to permit differential levels of local or regional institutional development to be taken into account.

3.3 Exhortation has no lasting impact, and coercion is unacceptable. Internal reorganization has often failed to resolve major problems. In Pakistan, there are apparently unbridgeable differences in opinion and interests between the legislature and administration. This results in little administrative independence for the irrigation agency, which anyway faces a multiplicity of objectives (many of which are neither commercial nor consistent). The user group approach has potential, but only where the organization is cohesive and well developed. At present, this is only likely to apply to a limited area in Pakistan, mainly small-scale schemes in Balochistan operated under longstanding tribal arrangements.

¹. Outside IBIS, in small, largely independent schemes, common in Balochistan and NWFP, communal user organizations are likely to be able to begin to manage such systems without delay, and in many instances are doing so now.
3.4 While the institutional and legal aspects of any restructured system should be flexible, the basic elements must be present. Options will vary depending on the social development of the local area. Where democratic and developed farmers' organizations exist, they should, together with other user groups, (local governments, industry associations, and environmentalists, for instance) take over system operation. In practice, this has only occurred in a few countries—Spain, Chile, the US, and (most successfully) Mexico, for example. Although the Bank supports such user organizations, their development is slow. Even in Mexico user organizations must pass through a well-monitored development phase before the system is turned over to them.

3.5 A public utility will also permit the needed two-way links between the supply and demand sides of the irrigation water market. Financial self-reliance will provide the stimulus for utility management to ensure cost-effectiveness and profitability. It will also provide the incentive to collect water-delivery charges and those for other services, thus restoring financial discipline in users. Users in turn will demand improvements in operations. Farmer Organizations (groups of individual users), would be a counter balance to the monopoly power of the utilities. Finally, legalization of water sales between users will permit efficient pricing of water in local markets, leading to more efficient on-farm water use. Linking drainage service charges to water delivery charges for collection by utilities could enhance drainage cost recovery, ensuring financial viability for drainage O&M and helping with finance for drainage expansion.

The Solution

3.6 The structure proposed here approximates the present provincial structure, because the essential tasks remain unchanged and disruption is minimized. The functions of the provincial irrigation department are divided horizontally between the public utilities and a provincial water authority (PWA). A provincial regulatory authority (PRC) would be required for the utilities (PUs) and user organizations. The federal authorities' role remains unchanged.

3.7 Public utilities would be created at the canal command level. This size is large enough to capture any scale economies in administration, yet small enough to provide much needed responsiveness to users. This would also allow a reasonably broad base for comparative assessment of managerial efficiency. The public utilities (PUs) would be responsible for delivering provincially allocated canal water to users in the command and collecting charges. It would also collect charges on behalf of provincial and federal authorities for their irrigation and drainage services. The PU structure may be seen as an interim development, until user groups mature and takeover the system's operation. In Balochistan, where tribal farming systems already exist, utilities can, with some technical assistance, likely be operated by the tribal user organizations.

3.8 Farmer Organizations will have to be fostered effectively. Farmers are the principal users of canal-water delivery systems. These organizations would not only represent users interests in dealing with the utilities, but also take over some of the activities such as water delivery to its members as well as collection of water charges. FOs would be encouraged to purchase water delivery services wholesale from utilities, and to organize O&M by members, thereby lowering the cost of delivery. Other services could also be performed by FOs, including provision of inputs and technology.
3.9 **Provincial Water Authorities**, as administratively autonomous agencies¹, would implement the responsibilities and obligations of the provincial government in the water sector. The "public good" elements of the water sector would define the boundaries of the PWA’s responsibilities. Also, for the foreseeable future the PWAs would be responsible for development and O&M of major provincial storages, link canals (for inter-river transfer of water), barrages and other provincial facilities used for delivering water to PUs. A major responsibility of the PWA would be the provision of provincial off-farm drainage and flood protection services, including planning, programming and implementing these. The PWA would be responsible for acquiring a province’s share of water under the Indus Water Apportionment Agreement and distributing this to the public utilities at the canal command level. All physical work on system O&M and development would continue to be contracted out.

3.10 **Provincial Regulatory Commissions** would be established to review, sanction, and monitor the utilities’ financial affairs, and specifically delivery charges for canal water. Simply establishing a utility is not sufficient, since delivery of irrigation water remains a monopoly. This market imperfection needs to be addressed to control monopoly pricing, reduce efficiency loss, and provide equity in distribution. The PRC would require the utility to undergo an annual independent audit to ensure financial transparency and accountability. The PRC would also arbitrate in disputes over water distribution, as well as oversee (and maintain a register of) individual water rights.

3.11 **Federal Authorities**, specifically the Ministry of Water and Power and WAPDA, would continue to take the lead in planning, provision, and O&M of interprovincial facilities for canal water capture, storage and delivery, and for drainage and flood protection. The cost would be recovered through user O&M charges. The Indus River Basin Authority would continue to implement the Indus Apportionment Agreement, which allocates water among the provinces. Federal authorities would also be responsible for developing (and monitoring and enforcing) quality standards for river and ground waters.

3.12 **Drainage and Flood Protection**: Because drainage is a public good, the primary responsibility for provision and O&M of drainage and flood protection services rests with the public sector, both federal and provincial governments. The delivery agency (the public utility) has the opportunity, however, to play a unique role. But steps will have to be taken to avoid unnecessary monopolies.

3.13 A three tier drainage system is proposed. Interprovincial drains and flood protection would remain with federal authorities. The PWA would be responsible for development and O&M of provincial drainage and flood protection. As monopoly suppliers of canal water, PUs have a unique ability to collect drainage cost recovery charges on behalf of the PWA together with irrigation water charges. The PWA could also contract with PUs to carry out drainage O&M within their own CCA. To preserve competition, however, all PWA contracts for drainage construction, contract management, and O&M should be awarded under competitive bidding. Farmer organizations may develop local-area drainage schemes, through contracts with PUs or private contractors. Finally, farmer and other user organizations may internalize collection of drainage charges or use the utilities’ collection facilities.

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¹ A specialist agency (i.e. the PWA) appears necessary to manage the provincial government’s responsibilities in water resource management. This activity is currently carried out by the PID. However, the efficiency with which it can operate is severely constrained by numerous administrative regulations and procedures. These regulations and procedures, which are needed to harmonize the core operations of government, are frequently not relevant and often an impediment to execution of the water resource management responsibilities. Consequently, the PWA should be administratively independent of the core provincial government, and having its own regulations and procedures as set out by the provincial government in the ordinance establishing the agency.
3.14 An optional two-tiered system would charge the PUs with the responsibility both for provision of all off-farm drainage needs and for cost-recovery which could be tied to irrigation water charges. Such charges would come under the regulatory oversight of the PRC. The PWA would likely still be required for overall planning and coordination of provincial drainage development in addition to its other responsibilities.

Towards the Long Run

3.15 Progress from the current to the proposed structure also involves phasing in a legal arrangement. As well as legislation for the proposed public-sector institutional changes, laws will be needed to develop water property rights. Property rights are necessary to realize efficiency gains, improve equity of distribution, legitimize water sales, reduce conflict, and promote long-term investment (Box 3.2). Without clearly defined (community or individual) property rights, reallocation of water is restricted to informal local exchanges. Lack of individual property rights gives tailend users no legal basis for any formal claim for loss of canal water resulting from misappropriation by headend users. As a result, tailends of water courses fall into disuse as farmers resort exclusively to tubewell water. This creates heavy and unnecessary pressure on the groundwater resource.

Box 3.2 Water Rights - Volume or Share of Flow?

Volume: A basic water right can be individual ownership of a specified volume of water contracted to be delivered annually to a preselected point in subvolumes and at agreed intervals. Some arbitration is required to finalize the volume, which must allow for variations in aggregate amounts, in storage or captured from the river, due to weather variations, as well as seminal decline in storage capacity due to reservoir silting. The time and place of delivery will depend on how users are organized. Delivery to an individual farmer’s intake point would likely be costly, but, a watercourse with a well organized user group might wish to capture some of the delivery cost themselves and receive the entire volume at the watercourse intake point (mogha) or even at a distributary or minor. Logically, there is no limit to this vertical integration process within the overall system, as long as sufficient gains to users are available. Sale of consumption rights should be unrestricted to permit market reallocation of resources. If development of a local private monopoly is of concern, the public utility or user organization may be given the first right of refusal, and thus act as a market maker.

Share of Flow: It is also possible to define a basic right by share of flow, which is formalization of the present system. This automatically transfers the risk of variations in volume to users. It also eliminates the need for metering the flow, provided that the basis for water charges remains unchanged. But this is unlikely to be the case, as true volumetric pricing is needed to eliminate rent seeking. Other factors militating against this approach are: the inability of share of flow to address the tailender equity problem, and the reduction in the size of water market due to increased uncertainty and thus increased transaction costs. As a result, volume based rights, where technically feasible, seem preferable.

Pilot Projects are vital to assessing alternative approaches. They should be carefully designed both to permit flexibility at the local level in determining the basis for property rights and to provide as much information and insight as possible on the performance of the system adopted for use in future projects.

3.16 Where the cost of establishing individual rights is high relative to the value of output, it may be better to define communal rights, such as where farms are uniform in size, or where there are

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equitable user organizations (which can ensure individual rights). Communal rights are frequently simpler to implement but legislation must set out guidelines for individual rights set by the communal (user) organization, including operating rules and voting rights of the user organization, as well as an appeals process for individuals who disagree with the resulting individual allocations. Communal rights may be appropriate for small independent systems, such as those found in Balochistan and NWFP. In practice, it is likely that there will be a blend of the individual and community approach. Government is unlikely to establish individual rights without wide local consultation to ensure transparency, and acceptability. Where as user organizations are likely to seek government agreement and registration of individual member rights to provide authenticity and thus permit enforcement of user-organization established rights.

Box 3.3 Water Rights and Poverty Alleviation

Most water would appear allocated according to land ownership. Water rights for landless farmers (tenants and sharecroppers) would ideally be part of a rural poverty alleviation strategy aimed at providing income generating assets to the rural poor. Because water is historically associated with land-ownership, any such program is likely to result in eviction of tenants, leaving them worse off. Consequently, allocation of water rights to these should not be attempted at the outset of any institutional legal restructuring program nor in connection with any initial determination of water property rights. In the long run, as more water becomes available through increased delivery and user efficiency, government may wish to consider a program to purchase and allocate this water for poverty alleviation programs.

3.17 Combining property rights with a formal water market provides a clear value (opportunity cost) of the resource, and thus a basis for profit-maximizing decisions. Substantial gains to sectoral output and farm income are available from reallocation of water among crops. In the absence of individual or community water property rights, realizing these gains and providing equity in distribution of water is impossible. The major beneficiaries would be large landowners (zamindars), as they could generate the most productivity gains, as well as large revenues from sales of surplus water. Conversely, zamindars suffer the greatest potential loss if the system remains underdeveloped.

3.18 In Pakistan, informal trade of tubewell and canal water indicates that gains from water trading are possible, although technical and legal obstacles need to be addressed (Box 3.4). A legal private market in water rights could greatly reduce transaction costs. It is likely, too, that a service industry of private water brokers will develop. This should be encouraged as a means to efficient information gathering and dissemination, as well as reducing contracting costs. A competitive brokerage industry can be seen as a sure sign that information and contracting costs can be privatized.

3.19 There must also be legislation to deal with third-party issues arising from private sales of water and disagreements arising out of such sales—for example, reduction in the availability of groundwater as a result of sales of surface water out of a particular hydrological area. Such effects have implications for ground water rights, the right of surface delivery systems to improve delivery efficiency through seepage reduction, and for allocation of delivery charges for basic water allocations and sales of savings. Whose property is canal seepage? If it belongs to the delivery system, should private tubewells be charged for its use? If so, should there be a concomitant reduction in charges for water delivered to the watercourse? If it is the users’ property, how is it allocated among them? And can they sell it inside and outside the hydrological area?

3.20 Surface Water Rights Allocation: Free distribution based on historically allocated entitlement would legalize these rights, give consideration to current users (particularly smallholders and tailenders),
Box 3.4 Feasibility of Water Markets in Pakistan.

1. Trading of irrigation water in Pakistan was never formally considered because of perceived infeasibility due to: canal flows being fed primarily from the run-of-the rivers; large distance from the reservoir; operational difficulties of large sized canals (discharge, area covered and length); absence of appropriate control structures; impossibility of shutting down canals for long periods to construct these controls; and the assumption that more control means more power for PIDs (which are not trusted by the farmers). All of these require substantial forward planning of water use and much reduce the possibility for "just in time" type decisions in purchases and sales. Remodelling of several large canals has been proposed to supply more water, but significant progress has not been made, although these projects are considered economically viable. On the other hand, lining of distributaries and minors is now a common development, and economically feasible, especially in saline groundwater areas. At the time of lining, the incremental cost of providing control structures is minimal, and, with the gains to be made from reallocation of water, the returns are very high, making it cost-effective to start the establishment of water market from the tail end of the system. At the lowest level, moghas are now used to measure flows from minors to watercourses. Simple flumes or weirs may be added for measuring flows in watercourses.

2. WAPDA surveys show water trading currently on 70 percent of all water courses, despite prohibition by the Canal and Drainage Act (1873). This act ties water allocations to specific plots and also ties land and water sales. The Land Reforms Act (1972) makes landowners responsible for water charges. Amendments to these are required to legalize water trading and create independent water property rights.

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1 Storage is only 16 percent of total diversions.
2 The Rohri canal commands an area of 1.1 Mha, it is about 200 mile long from head to the tail regulator and its discharge capacity is more than 450 m$^3$ per second.
3 To recover 1.0 Maf reduction in allocation under the Water Accord, Punjab Province plans to embark on a large program of lining distributaries and minors.

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and provide stability and continuity to the current situation. This stability and continuity is both economically and socially desirable. For the existing system, no contribution to recovery of capital costs is sought as inclusion of these in an equitable fashion is difficult. This is because an unknown sum has already been collected through betterment charges and sale of public irrigated lands to farmers, and through the pre-1974 surpluses generated from O&M. Also, the contractual obligation of those users to pay is unclear. Distribution without charge avoids large scale disruption, which would be costly. There is some risk that tailenders and other small farmers, having little or no confidence of receiving water, may choose to sell water property rights in favor of continued pumping of ground water. This would defeat the effort to ensure equitable distribution (particularly in saline ground water areas) and reduce groundwater pressure (particularly in fresh ground water areas). Active involvement by user organizations to promote equitable distribution through individual water rights will be critical in addressing this concern and promoting member confidence in the user organization.

3.21 **Ground Water Rights Allocation:** WAPDA should assess the safe volume (yield) of annual extraction from the groundwater aquifer in a canal command. Of this volume, the equivalent of contribution to the aquifer from PU canal-water system would be allocated to the PU, and the rest to farmers based on their surface water allocations. In fresh groundwater areas, groundwater allocations may be reused for irrigation or traded. In areas requiring drainage, the cost of drainage should be charged to farmers organizations and utilities on the basis of their groundwater allocations. Enforcement by WAPDA of the predetermined safe volume of groundwater extraction should be at the FO and PU levels. The FOs, in turn, should be responsible for enforcement at the level of the individual user.
3.22 **Ground Water Quality:** WAPDA and other agencies, (particularly the Federal Government’s Environment and Urban Affairs Division and the provincial government’s Environmental Protection Agencies) will need to establish comprehensive ground water quality standards. They will also need to determine the contribution to degradation of ground water quality from different areas and activities, including agriculture. These are needed for development of a system of monitoring of quality changes, assigning responsibility for these, and determining corrective measures. For agriculture, most water quality control issues are closely linked to drainage, and there is evidence of substantial trade-offs (both positive and negative) in relation to quality control between provision of drainage and restriction of on-farm activities and input uses.

3.23 **Development of Farmer Organizations:** The current legal framework for farmer organizations requires further development. Past experience has shown three recurring problems: i) asymmetry of incentives to organize arising out of watercourse location; ii) insecurity of land tenure; and iii) inadequate institutional development. These are concerned with the need to: offset the likely anti-user-group efforts of headend farmers, who already capture substantial rents from canal water; shield tenant farmers and sharecroppers from developments which might jeopardize their already fragile access to income-generating assets; and, prepare for a long-term institutional development process in promoting successful farmer organizations.

**Pricing of Irrigation Water**

3.24 An efficient allocation of water in the long-run is characterized by equalization of the marginal value product of water and the marginal cost of supplying it, (that is, the resource cost). If demand for water cannot be satisfied in the short-run by charging marginal delivery cost, capacity constraint exists. If so, an optimal allocation is achieved if the marginal value product of water in one use reflects the opportunity cost of foregoing its use in the best alternative activity - that is, if marginal value products are equalized. If in an ideal irrigation system, in which the water utility has the flexibility to supply water in response to user demand, the market price for water assumes the role of distributing it optimally since irrigators will bid up the price of water till marginal returns are equalized. If the price does not reflect opportunity costs, over-consumption and wastage occurs.

3.25 The Indus Basin system operates at its capacity limit; thus, the opportunity cost of one unit of water (its marginal value product in agricultural use) overestimates the short-run marginal costs of running the system. The system was designed to make water receipts proportional to land holding. If all farms had the same agricultural production function and were equipped with the same inputs of other factors (such as labor, fertilizer and tractors), this would result in an efficient use of the limited resource. However, there are substantial variations in the efficiency of water between regions and crops which cannot be explained by diverging transportation and delivery costs. The average financial return to water is 700 Rupees per acre foot, but ranges from zero to 2000 Rupees. These data also suggest

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1. An equalization of marginal value products assumes that delivery costs are equal. If substantial divergences in transportation costs exist, net rents are equalized (marginal value product minus marginal cost of obtaining it).


3. Data based on a sample of farm budgets assembled by World Bank staff. Variations in returns can be observed both for different crops within one region and for the same crop between regions. For example, returns to water in Gujranwala are as low as 11 Rupees per acre foot of water for basmati rice and 973 Rupees for sunflower seed. The return to water in sugarcane production in Faisalabad is even slightly negative (-10), while in Mandian it is 182 Rupees per acre foot.
Box 3.5 Bank Water Pricing Policy

Bank policy on irrigation water pricing, set out almost 20 years ago, invokes three principles—efficiency, income distribution, and public savings. These were developed in an investment-project framework, with pricing in new investment projects considered independent of ongoing country practice. Inconsistencies arising between efficiency pricing and income distribution, and public savings and income distribution were not addressed. Guidance on the use of the additional criteria of sustainability and replicability was not provided. As a result, in terms of their implementation in any particular project, the principles are utilized as general guidelines and indicators, rather than firm policy directives to be followed in establishing the structure and levels of charges and taxes for each project. They have been largely unattainable, due to the very high transaction costs, and the almost inevitable breakdown of discipline in a bureaucratically administered system. Subsequently, the world-wide O&M financing crisis restricted the focus of implementation to public savings in the form of cost recovery. Currently under review, the policy is turning towards incentive-driven efficiency and discipline, with opportunity cost as a basis for this.

Bank policy also calls for water charges to contain an element that taxes water users progressively, thereby reducing income inequality in the agricultural sector. A two-tier system of charges can create a progressive tax, and also one that is acceptable locally in the sense of charging rich and poor alike the same per unit for the same delivery service. With legalized water markets, cost recovery, equity and efficiency objectives could then be achieved simultaneously. The price per unit of water reflects the direct delivery costs associated with the volume of water delivered, while a fixed charge is levied unrelated to the volume of water used. This fixed charge can then be adjusted so as to meet the costs of the utility, including connection costs and other financial burdens. It may also be set progressively, increasing with the size of landholding.


significant variations in marginal returns to water. The prices in informal local water markets show huge variations. Privately pumped tubewell water prices range from 100 to 400 Rupees per acre foot; even informal water sales which take place along a watercourse show a range of 100 to 700 Rupees per acre foot of water. Equalization of marginal returns to water is practically impossible, due to external impacts after the cropping decision has been made. But the large divergence in returns and prices signals high potential output gains that could materialize if the available water is allocated more efficiently.

3.26 The current rate of fresh groundwater extraction is not sustainable for most aquifers. Fresh groundwater pumped by private tubewells is priced in two ways—via inputs and area assessment. Owners of electrical tubewells are charged a flat rate per month. The fixed cost nature of the electricity charge induces owners to pump as much water as can be used or sold from the groundwater aquifer since the marginal cost of pumping is low (only the marginal maintenance cost). Diesel tubewells, on the other hand, are run at a variable operational cost (the fuel). Moreover, crop-area assessment of water use also captures the use of tubewell water.

3.27 Public-utility theory advocates that utilities price their services, even in times of excess capacity, at long-run marginal cost (LRMC), because investments are generally lumpy and have a long gestation period. In this way, consumers are made aware of future costs imposed on the system if demand increases.

1 Since water, not land, is the constraining factor in agricultural production, average and marginal productivities of water can be expected to move close together.
3.28 Data constraints make it difficult to assess actual LRMC for the individual users and to disaggregate the individual categories of marginal costs. Practical billing necessities often render detailed LRMC pricing uneconomical. Similarly, for political reasons, unified regional or provincial rates might have to be adopted. Irrigation agencies often supply water to remote areas, where marginal costs outweigh the opportunity cost. In such cases, government should pay the agency the difference between the delivery cost and the O&M charge prior to actual delivery (that is, the cost of implementing the social program). But, these programs are troublesome, diverting the agency from its basic objective of cost-effective delivery of irrigation water. They also cause breakdown in user discipline, as more and more users seek preferred treatment, expanding the beneficiary group until the program becomes a severe financial burden to the public sector and even a macroeconomic issue.

3.29 Creating user water rights and legalizing water trading can be expected to provide a transparent market value for water, and its opportunity cost of the factor. This promotes more efficient use of this scarce resource, through equalization of the marginal value product of water in its alternative uses.

Cost Recovery

3.30 Replacement of PIDs with public utilities, coupled with development of water markets based on water property rights, permits not only efficient water pricing but sustainable cost-recovery. Cost recovery is essentially a delivery charge per unit volume of water which covers current full O&M costs only, including those of provincial and federal water authorities. It is not proposed to include past capital expenditures. All future investment costs, however, both for additional and replacement capture, storage and delivery, are expected to be fully recovered, from either delivery charges or sale of rights, or both. Long-term development planning must allow for this in estimating future irrigation demand and these costs must be made explicit by utilities in delivery contracts with user organizations.

3.31 For users, delivery charges covering full O&M costs are financially feasible, not burdensome. Current O&M charges are only 5 percent of either costs of production or farm income, while recoveries average 70 percent of charges. With full recovery of current O&M charges, the rate charged would only need to be doubled to meet full O&M requirements—still less than 10 percent of farm income. With no increase in delivery efficiencies, the increased charge amounts to Rs 40 per acre-foot at the mogha and Rs 70 per acre-foot in the field. This compares to financial marginal values for water of Rs 700 per acre-foot, informal market values of Rs 100-700 per acre-foot, and private tubewell water prices of Rs 100-400 per acre-foot. The O&M charges will be reduced to the extent that the FOs take over O&M at the distributary level and improve delivery efficiency here. Also, significant efficiency gains below the mogha can be made through FOs. For example, under the On-farm Program, efficiency between the mogha and the field is currently being increased by an average of 7 percentage points.

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1. The LRMC can be subdivided in marginal capacity costs, representing investment costs of new facilities, marginal operating costs (increasing the water supply with given capacity) and marginal customer costs which are directly attributable to the water users (connection to water supply, assessment and billing costs). Mohan Munasinghe, "Principles of Water Supply Pricing in Developing Countries", World Bank, Latin American and the Caribbean Region Series IDP-19, 1988, p.22.

2. This is in line with present practice in Chile, where investment costs are fully recovered based on individual water rights. (World Bank Staff Appraisal Report No. 10850-CH. Chile Irrigation Development Project, (para 7.13). October 1992.

3. WAPDA’s costs are attributed mainly to power production and supply. Irrigation related O&M costs are less than 5 percent of total provincial O&M costs, and so readily covered under a doubling of O&M charges.
3.32 Pricing of delivery services by the PUs must be regulated to prevent market imperfections leading to discriminatory pricing practices and misstatements of costs in establishing the basis for cost recovery. A generally used yardstick of financial viability is the potential to earn an acceptable return on assets (such as the net operating income) as a fraction of net fixed assets plus working capital. An upper limit to returns imposes a restriction on average water charges. If regulated in this way, priority would be given to achieving the financial objective of self-sustainability. Possibilities of following more closely the long-run marginal-cost pricing approach might be explored - that is, charging the different blocs of buyers some fixed connection charge and attempting to price the unit of water at its marginal cost while taking into account possible future investment projects.

3.33 Regulation to ensure adequate investment in system expansion appears unnecessary. At first, prospective water supply investment by monopolist utility may appear to be less than in a fully competitive system. But, competition from basic water rights holders (totalling about 75 percent of captured water) and groundwater, as well as other utilities would, in the long run, ensure a competitive system. In development of new storage, the utility will not have a monopoly as competition will come from federal and provincial governments, other PUs and the larger, more advanced FOs. Thus, again, regulation is not required for this. In fact, the PU has a monopoly only in delivery of diverted water and regulation of a PU should be confined solely to charges for this.

Water Markets: Cross-Country Experience

3.34 Bank experience with water markets is limited. Past irrigation sector reviews commonly focussed on improvements in performance of existing government O&M institutions. Efficiency pricing, considered in an administrative sense, was correctly seen as unattainable. Also the world-wide cost-recovery problem focussed much of the operational emphasis on the concern for sustainability. Chile, in addition to the US, provides an excellent example of agricultural water markets. In the US, the main concern is with intersectoral transfer in western states. Also, the markets are inhibited by regulations constraining movement of water out of agriculture without any clear rationale. The feasibility of water markets in the US and their potential for superior resource allocation is unquestioned. The implied rationale of the regulatory stance and its cost are the major concern of most work.

3.35 In Chile, the reformist Water Code (Decreto con Fuerza de Ley 1122) of 1981, while restating the constitutional position of public ownership of all water resources, provides for the creation of individual property rights as freely transferrable and mortgageable assets, independent of land. This has permitted allocation of water by market forces. The resulting market pricing of water and unlinked transferability of water and land is said to "have fostered efficient agricultural use of water, allowing the country to increase its productivity--generating more production with the same, or even (because of transfers to urban uses) less water." Transfers of water rights must be approved by the National Water Authority and are monitored by it and the local user association. These monitoring points may be used


2. Competitive firms expand production to where marginal cost equals price, but monopolists expand only to where marginal cost equals marginal revenue.

to resolve dispute over sales. The Bank is actively involved in development of this system. In Valencia, Spain, property rights in both water and land have been historically separate since the late 16th century and independent trading in water rights was practiced. A comparison of this market-based system with neighboring warabandi-like (rotation and turn) systems shows the market system performs better in generating more net income, especially in times of water scarcity. In New Mexico, the impact of physical third-party effects has been mitigated by defining rights in terms of consumptive use only.


IV. FARMER ORGANIZATIONS

4.1 Farmer organizations (FOs) can make a unique contribution to the welfare of farmers and to the development of Pakistan’s irrigation and drainage by providing a counterbalance to the monopoly of the public utilities, facilitating water market development, and reducing administrative and O&M costs.

Experience in Pakistan

4.2 Water Users Associations (WUAs) under the On-Farm Water Management (OFWM) Program:
In Pakistan, farmer organizations began in 1981 under the Bank-supported OFWM. These Water Users Associations (WUAs) were formed at the watercourse level. The primary objective of OFWM was to rehabilitate watercourses and WUAs were an effective means of organizing farm labor for this effort. By 1991, there were over 17,000 WUAs, representing about 16 percent of all watercourses. The OFWM Pilot Project relied on the traditional "khal committee" as a vehicle to mobilize labor for rehabilitation of watercourses. This proved to be ineffective. Studies of the Pilot Project concluded that maintenance could only be assured if farmers were formally organized into legally recognized user associations, empowered to enforce watercourse maintenance. Therefore, farmers seeking assistance under the first OFWM project were required to form a WUA, registered under provincial ordinance. OFWM envisioned WUAs providing farmers with: (i) a vehicle for carrying out construction and O&M activities at the chak level; (ii) a collective voice in planning, construction and operation of irrigation and drainage facilities; and (iii) a mechanism for conveying irrigation-related extension information.

4.3 Though well-intentioned, OFWM's approach to develop FOs did not work well. Because registration of a WUA was a precondition for participation in the program, the WUAs often came to be perceived by the farmers simply as a means of obtaining project assistance in watercourse improvement. Once this was achieved, many WUAs became dormant. Further, because improved watercourse technology reduces the frequency of maintenance and cleaning, the program may reduce incentives for the farmers to take group action, either through a traditional "khal committee" or a modern WUA. There are exceptions, however. Some WUAs have remained active after the completion improvement works and have played a particularly effective role in resolving conflicts.

4.4 Several attempts were made to address problems of sustaining WUAs. These included an increase in technical assistance, and provision of irrigation agronomy teams to assist WUAs in O&M, efficient irrigation technologies, and liaison with the local Extension Service personnel. The results of these changes have not yet been assessed, but general understanding is that the WUAs have not improved significantly.

1. The "khal committee" is comprised of three or four elite members of a village, including the village headman serving as the committee's chairman, who traditionally organize cleaning and maintenance of the watercourse.


3. The chak is the tertiary irrigation command.

4.5 Village Organizations (VOs) under the Agha Khan Rural Support Program (AKRSP): The AKRSP in the Northern Areas of Pakistan was successful at organizing rural communities on a self-help basis. The AKRSP is based on the development of participatory Village Organizations (VOs) in which villagers, led by village activists, act as the prime movers while the program organization serves the role of catalyst. By mid-1989, the AKRSP had established more than 1,000 VOs, comprising 53,000 households, representing about 54 percent of the total rural households in the Northern Areas.

4.6 The Bank has evaluated the performance of the AKRSP in meeting two of its major objectives: (a) involving the people of the three program area districts in their own development and (b) providing a model of rural development in other settings. The Bank evaluation report concludes that the program shows continuing and remarkable success in its approach to participatory development. However, the question remains as to whether this approach can be used in other areas endowed with different geopolitical and socioeconomic environments.

4.7 Civil Canal Systems in North West Frontier Province (NWFP): NWFP has several privately operated canals called civil canal systems. These were originally built, and continue to be operated, by farmers. In a civil canal system, river water is diverted into a canal that delivers water to watercourses by gravity. Sizes of civil canals vary, with some serving several villages. Maintenance of the system, watercourses, canals and diversion structure at the river is carried out by the farmers. They also meet the cost of O&M. The warabandi schedule, however, is prepared by the PID. For system maintenance, farmers organize themselves informally at two levels—at the watercourse level and the canal level. Water allocation for civil canals (about 3.7 Bcm) is 2.5 percent of the total allocation under the Provincial Water Accord. While total area irrigated by the civil canal is not available, the total water allocation shows that it is significant.

Water User Organizations—Cross-Country Experiences

4.8 User participation in irrigation management is not new and the Bank has wide experience here. Communal irrigation systems have existed in other countries, such as Thailand, India, Sri Lanka, Bali, Indonesia, the Philippines, Nepal, and the Dominican Republic. Experience indicates that active farmer involvement in irrigation is very cost effective in mobilization of local resources, improvement and maintenance activities, reduction of irrigation department staff time, reduction in the destruction of facilities, fee and fine collection, resolution of disputes, and provision of an organized means for extension and farmer training. Recognition of these benefits (and a realization that many of irrigation performance problems were poor O&M, brought on by government institutional failures) led to a marked increase in the development of user associations in the past 20 years. Developing country experiences with WUAs vary considerably, but valuable lessons can be drawn for Pakistan's strategy. Histories of successful indigenous system development, however, reveal a common pattern: successful

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4. It is estimated that at present about 45 million ha (or one-third) of the irrigated area in Asia is operated and maintained by about 500,000 associations. See: Toru Mase, "A Study of Water Users' Associations for Irrigation in Asia", Journal of Irrigation Engineering and Rural Planning, Number 18, February 1990, pp. 5-16.
user associations develop simultaneously with the planning, construction and expansion or creation of the physical system—often over a period of many years.¹

4.9 One of the most successful government efforts to promote user participation in irrigation management is the Philippines. There, more than 5000 communal irrigation schemes cover almost half of the irrigated land. They conduct O&M and operate on a self-financing basis with technical assistance from a network of Irrigation Community Organizers (ICOs) (Box 4.1).

4.10 In Indonesia, the government sought to turnover small-scale irrigation systems to WUAs, when under-financing of O&M began to threaten system sustainability. The WUAs were given legal rights and technical assistance to take on management responsibilities. Since 1987, the government has transferred more than 400 systems, covering more than 34,000 ha, to WUAs. Success of the program is said to be due to early inclusion of farmers in design and creation of the WUAs.

4.11 In Nepal, 70 percent of all irrigation is now under farmer control. Expansion of the system in recent years has been helped by a Bank-financed Irrigation Line of Credit Pilot Project. The project extends credit to WUAs which contribute to capital costs for construction of new subsystems and take over O&M.

4.12 In the Dominican Republic, management of irrigation and drainage systems is transferred to WUAs in two project areas, Azua (YSURA) and Santiago (PYRN Contract I), with total area of 14,400 ha, serving 6,000 farm families. A water users group (Nucleos) was formed on each sublateral. Distribution of irrigation water is controlled by Nucleos after it leaves the lateral canal. The Nucleos on an irrigation lateral subsequently formed a WUA (Junta) that encompassed a complete lateral. After transferring the system to the WUAs the cost recovery and O&M of the system has improved significantly.

4.13 Interest in (and new approaches to) farmer-managed irrigation schemes has grown in Latin America as well, most recently in Mexico (Box 4.2). In Argentina, traditional user organizations (whose members held a total of 100 to 500 ha) were found to be too small to meet the associated costs. Maintenance was insufficient, water management was weak, and headenders benefitted disproportionately. To capture the economies of scale, these associations merged into larger ones with 5,000 to 15,000 ha. Twenty-one new organizations were formed, covering 200,000 ha. Each organization is autonomous, finances its own expenditures, and issues its own regulations in accordance with the newly-enacted water law. Each hires professional managers to take charge of for example, water delivery, cost recovery, and maintenance. Not only are administrative costs are lower, but the larger organizations have increased conveyance efficiency by 10 percent.

**Need for Farmer Organizations**

4.14 If Pakistan’s farmers have managed their own watercourses for decades without formally organizing, why change? Pakistan’s irrigation system was built to serve fewer farmers, holding larger acreage than today. Migration and land fragmentation have put greater pressure on already scarce water resources.² In the process, discipline has broken down, theft is increasingly common, and inequity

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Box 4.1 Water User Organizations in the Philippines

1. From its earliest days the National Irrigation Administration (NIA) in the Philippines has encouraged formation of Irrigation Associations (IAs) in National Irrigation Schemes. An IA for each 50 ha turnout unit is in principle registered as a non-profit/non-stock entity under the Securities and Exchange Commission, giving it the legal backing to enter into agreements with NIA and other agencies. Each IA has a formal constitution with a chairman, board of directors, and officers. They are responsible for O&M below the turnout, and for coordination with NIA staff on water supplies and system maintenance. In principle, IAs can be federated along laterals, though this has occurred in only a few cases (for example, the Magat River Integrated Irrigation System).

2. Despite NIA's continued efforts, IA performance was mixed and many failed to sustain an active role in irrigation management. Several measures were taken to strengthen their performance. First, the NIA's Institutional Development Department (IDD) staff were fully integrated into regional and project management. Resistance from engineering staff was overcome, and NIA is perhaps unique in having transformed its staffing patterns to reflect these new requirements. Second, agents to catalyze IA formation and sustain their functioning were introduced. This role is performed by a Farmer Irrigator Organizer (FIO), temporarily recruited from the local community, supervised by NIA staff, and paid a small honorarium. This approach is inexpensive, avoids the need for contract staff, and provides benefits to the IA, as the FIO remains in the village once tasks are completed. Third, experience suggested that O&M within the turnout area was inadequate to sustain IA activities and attention has been given to widening their functions through contractual arrangements with NIA. A three-stage approach is used. In Stage I, the IA contracts to maintain a section of the watercourse and to assist in operations and fee collection. In Stage II, the IA both maintains a section of the watercourse and collects water fees from its members based on a graduated incentive system. In Stage III, full responsibility for up to 1,000 ha is transferred to the IA, in effect turning it into the equivalent of a communal system. The number of IAs with formal O&M contracts rose from five in 1981 to 581 at end-1989, covering almost 140,000 ha. Although there has been no comprehensive evaluation of the program to date, there is evidence that it has contributed to substantial cost savings for government.

3. The NIA has also pioneered the participatory approach to development and rehabilitation of communal irrigation schemes employing Irrigation Community Organizers (ICOs). There are more than 5,600 communal irrigation schemes in the Philippines, covering about 600,000 ha, or 48 percent of the irrigated area. These systems are owned, operated, and maintained by IAs, on a self-financing basis. Communal irrigation in NIA is yet to come under a regular department and is implemented through projects. Regional institutional staff guide provincial offices, which are responsible for implementation. The ICO is fielded after preliminary investigations are complete and usually is fully responsible for one core project where he or she lives and has part-time responsibility for one other project. The ICOs play a critical role in assisting IAs to develop financial management skills, starting in the pre-construction phase and continuing throughout the operational phase. Over the past 15 years, detailed procedures have been developed to guide staff. They are highly formalized to provide a full legal basis and increase farmer awareness and commitment. Sub-committees are set up for each major task and the aim is to involve all IA members directly in some capacity. The IA is responsible for all aspects of irrigation O&M. There is continued contact with NIA so long as the scheme is being amortized and further support can be provided. This participatory approach is strongly supported by farmers and has a strong prima facie justification.

4. Some evidence of the effectiveness of IAs has emerged from a recent study. It was observed that financial viability of IAs is more likely when there is a greater degree of hierarchical control with more official positions in the organization. However, it was found that IA performance (as measured by agricultural productivity) improves significantly when there are fewer employees, and where a greater proportion of membership is involved in decision-making for allocation and distribution of irrigation water. The NIA has apparently placed greater emphasis on establishment of hierarchical structures than on encouraging universal participation. Should farmers see this as an attempt to increase fee collection, there is a strong possibility that initial high participation will decline. This suggests that there are real risks of over-formalizing and over-populating user organizations.

Box 4.2 Transfer of Management of Irrigation Districts to Water Users in Mexico

1. In Mexico about 6.1 Mha are under irrigation, of which about 3.3 Mha are in 79 large scale irrigation districts. These districts vary from 3,000 to 270,000 ha, with average farm size of 6 ha. The irrigation system serving these districts were developed by the public sector. The low cost recovery (below 30 percent) and inadequate budgetary appropriations resulted in declining system performance due to lack of O&M. In response, the 1989-94 National Development Plan adopted a policy of transferring the management responsibilities of the Irrigation Districts to water users. Facilitated by a World Bank loan, the National Water Commission (CNA) has so far, transferred 36 irrigation districts covering an area of 1.5 Mha. The area transferred exceeds the original target by about 25 percent.

2. Transfer is in two stages. First, the responsibility of O&M of lateral canals and minor drains is given to the producers, which are organized in Users’ Associations. CNA requires that the Users’ Associations demonstrate their capacity to function before moving to the second stage. A minimum duration of at least one year is automatically imposed on stage one. During the second stage, the Users’ Associations form an Enterprise Association (Sociedad) which takes over the O&M of the main irrigation and drainage canals, as well as the machinery and equipment required for O&M. Only the barrage and the system above it is left with the CNA.

3. Water charges are collected by the Users’ Associations at the beginning of the season, covering the O&M costs of system in control of CNA, Sociedad, and itself. The Users’ Association then pays the CNA and Sociedad. With the transfer program, water charges have been raised many times. In the Yaqui district, for example, water charges have been increased from about US$12 per ha in 1987 to about US$60 per ha for 1992-93.

4. The User’s Associations have recruited competent professionals of manage the O&M of the system. To enable a Users’ Association to hire such assistance requires a minimum area per Users’ Association of about 3,000 ha. Most of the Users’ Associations range from 5,000-25,000 ha. Cost recovery is now around 80 percent, and the O&M of the systems has improved significantly.

abounds. Further, there has been a steady and marked decline in real O&M expenditures for the past few decades; as a consequence, less water reaches the mogha. Flows through watercourse are subject to leakage and theft, and what arrives at the tail, if anything at all, is inadequate. Given the Government’s fiscal constraints, an alternative O&M financing strategy must be pursued. The preferred course is to transfer greater control of the irrigation system to organizations of water users. Because traditional methods of decision-making among irrigators have not proven to be sufficient to shoulder these new responsibilities, cooperation among users, (not just within but among FOs), will be required to transfer greater O&M control from government and to enable water markets to function effectively.

4.15 Ensuring accountability of monopolies (public or private) is crucial. This is best achieved through a combination of regulation (service standards, reporting requirements, etc.) and consumer rights. Consumers, acting collectively and individually to protect their rights, and reinforced by legislation, help ensure accountability. The FOs must play a central role in assuring that PUs are accountable for service delivery, maintenance of physical structures, and assessment of charges.

4.16 FOs also have to help bring user discipline to water distribution. The fact that warabandi on a watercourse, which is implemented by the farmers themselves, is violated rarely (unlike illegal pumping from the distributary or minor canals) shows that the FOs can improve operation of the system. Therefore, their role should be expanded to the highest possible level in the system--at least to the distributaries and minors.

Promoting Sustainable Farmer Organizations

4.17 The strategy proposed requires development of fully functioning FOs. They will have a continuous role in the distribution of water to users. They will be responsible for the O&M of the system and will collect O&M charges from users. The FOs will have financial resources and powers to improve the delivery system and develop water supply, such as installation of groundwater tubewells and purchase of water from PUs or other FOs. They will be large enough to recruit competent professionals to manage the O&M. Also, technical and institutional development assistance will be provided to the FOs and they will be involved in the planning and development stage, when a canal command is converted to the new system. To enable the full functioning of the FOs, present restrictive legislation should be reviewed and replaced with a legal structure allowing autonomy to FOs.

4.18 In the proposed institutional structure, the PU has a direct commercial interest in the success of FOs. The PU has the advantage of having a permanent presence in the area and a multiplicity of common interests and concerns with FOs. In fact, apart from issues of income from water delivery and sales, matters affecting the overall welfare of the PU and the FOs are much aligned. Thus, the PU is expected to provide considerable assistance to FOs on a wide variety of technical, financial and social matters. Of course, technical assistance to FOs for institutional development (ID) can come from many sources, including assistance from concerned government departments, NGOs, and special bilateral programs, as well as from PUs.

4.19 Regardless of the source of assistance, it is vital that ID staff:

- operate under a mandate undiluted by other activities;
- be well trained in skills necessary for institutional development (for example, organizational principles, accounting, dispute resolution);
- focus sufficient resources for a sustained period of time and provide long-term follow-up to fledgling FOs;
- work closely with other sectoral staff to ensure that policies are coordinated.

4.20 A "cookie-cutter" approach must be avoided. Farmers from different watercourses and distributaries may have very different ideas about what their organization should and should not be. ID staff and farmers must work closely to clarify expectations and objectives, which will vary from place to place. By-laws may need to be amended to suit particular circumstances. FO membership may or may not include all members of one distributary, or may include members of multiple distributaries. Procedures for settling disputes might follow traditional methods or newly-developed guidelines. The critical point is that flexibility in the ID approach is a prerequisite for success.

4.21 Inter-agency Coordination: As they develop, the FOs are expected to progressively assume responsibility for coordinating all activities for their area to best utilize the irrigation system. This would include advance crop planning and coordination of water deliveries and technical input from line agencies. As the financial resources of FOs grow, they may acquire additional technical assistance and extension and other services as needed from private sources to supplement those from the public sector. Coordination among irrigation and agricultural activities would become the responsibility of the FOs on behalf of its members. In early transition, this coordination would be through the interaction of the emerging FOs with the PUs and line agencies.
V. OVERALL INSTITUTIONAL STRUCTURE

5.1 Irrigation and drainage in Pakistan is dominated by the public sector and performance of public institutions is a major problem. Increasing agricultural production, specifically crop yields, will require substantive improvement in water management. It will also call for better financial, managerial and technical planning. The performance of the sector will depend on clearly redefining the roles of government and private sector and enhancing their capabilities.

5.2 The proposed institutional structure provides a greater role for the private sector and autonomy for the public-sector agencies. In general, federal institutions would continue to be responsible for overall assessment, coordination and development of water resources and works of inter-provincial nature. An administratively autonomous Provincial Water Authority (PWA) would be responsible for coordinating all planning and development of water resources within the province. It will also handle distribution of irrigation water to financially-autonomous, independent public utilities (PUs) at the canal command level. At the production face, a FO would distribute water among its members. A Provincial Regulatory Commission would regulate the O&M charges of the PUs and adjudicate farmers’ disputes (Figure 5.1).

5.3 **Federal Government and Agencies:** Under the proposed structure, the role of the federal institutions will not change much. These institutions are the Ministry of Water and Power (MWP), WAPDA and Office of the Chief Engineering Advisor (CEA) and Ministry of Planning and Development. Development of appropriate legislation to establish water rights, development of water markets and PUs will be the responsibility of the MWP. WAPDA and CEA will continue to work as executive arms of the MWP and on its behalf they will be responsible for:

(a) assessment and intersectoral allocation of water resources in the light of demand patterns, and efficiency in use;  
(b) hydrological measurements, investigation, planning and monitoring of water above the rim stations, and watershed management;  
(c) monitoring and control of groundwater aquifer;  
(d) develop and implement criteria and programs for monitoring and enforcement of water quality in rivers and groundwater aquifers;  
(e) assessment and forecast of water availability, and preparation of basin-wide operational plans in coordination with PWAs and PUs;  
(f) delivery of water to PWAs;  
(g) coordinating flood control works and flood management;  
(h) planning, development, and O&M of large dams, inter-provincial link canals, and outfall drains (in response to long term needs identified jointly with PWAs and/or PUs) with full cost recovery for such services; and  
(i) recovery of O&M and capital costs of federal infrastructure through water charges, sales of water or revenue installments.
Figure 5.1: Proposed Institutional Structure
5.4 **Indus River System Authority:** IRSA was created recently to oversee the implementation of the Provincial Water Accord among provinces. Its role will not change under the new setup. It will lay down the basis for regulation and distribution of surface water among provinces, according to the allocation policies agreed in the Provincial Water Accord; review the reservoir operation; settle any disputes between provinces relating to distribution of river and reservoir waters; and evaluate the availability of water for all new projects.

5.5 **Provincial Water Authority:** An administratively autonomous Provincial Water Authority (PWA and akin to the federal WAPDA) would be responsible for delivering water to Public Utilities. These deliveries may consist of the basic water rights of PUs and water captured by PWA or water traded among different PUs. Total water use in each province will be according to shares allocated under the Provincial Water Accord. The PWA will recover O&M costs for the delivery of the basic rights volume. Any incremental water captured by PWA will be auctioned off. The PWA will charge transaction fees to recover costs involved in facilitating trading among PUs.

5.6 The PWA will be responsible for the O&M of link canals, barrages and other provincial facilities distributing water to PUs (although implementation may be contracted out). The PWA will plan and develop new facilities on behalf of PUs to improve water delivery efficiency, regulate water within the province, and enable sales among PUs. The cost of these activities will be recovered through the sale of water or revenue installments. The PWA would also be responsible for development and O&M of main and/or tributary drains, receiving drainage effluent from the FOs within the province, and for flood control and protection works and flood management within the province. To ensure a smooth transition to the new system, it is suggested that PWAs should be formed after PUs start functioning in most canal command areas.

5.7 **Provincial Regulatory Commission:** A Provincial Regulatory Commission (PRC) would oversee the financial affairs of PUs, register water rights and adjudicate local water distribution disputes. The PRC would have two separate wings. The regulatory wing will oversee the financial aspects of PU operations, including review and register of allocation of basic water rights, and regulation of PUs charges for delivery of basic water rights volumes. All water distribution disputes, including among the members of an FO, will be adjudicated by the arbitration wing. The PU will have no concern with any dispute among members of the FO, as long as the FO is paying water charges. If the FO does not pay water charges, the PU will be empowered to stop water supply to the FO.

5.8 **Public Utilities (PUs):** The PU is a key interim element in the proposed institutional structure. The PU would need to be a self-sustaining autonomous body, with a hard budget constraint, and provide services on commercial basis. The PU will have two separate wings—an operations and technical assistance. The PU may cover several canal commands. It would be desirable for accurate water accounting, however, that a canal command is not split among more than one PU. The main function of the operational wing of the PU will be to take delivery of water from the PWA and allocate this among FOs. Where contracted to do so by the PWA, it will undertake development, O&M and collection of charges for drainage and flood protection systems in its command area or elsewhere. The technical assistance wing will be responsible for helping farmers develop FOs and make decisions about technical options. It may hire services of consulting firms, NGOs or other agencies with expertise needed by the FOs. As the FOs mature, the activities of the technical assistance wing may be scaled down. A PU's revenue will consist of O&M cost (including O&M costs charged by WAPDA and PWA) for delivering water established as FOs basic right, sale of non-basic rights water to FOs or other PUs, and transaction fees for facilitating water trade among different FOs.
5.9 Major functions of a PU would be:

(a) operate and maintain irrigation and drainage facilities in its command area;

(b) collection of water delivery charges fees from the FOs, and collection of drainage service charges as contracted for by the PWA and federal agencies;

(c) pass on provincial and federal share of fees collected to the PWA and federal agencies;

(d) determine, in coordination with the FO, the delivery point at which the FO will receive water from PU. As the FOs mature and expand management capabilities, the delivery point should move higher up the system. During transition, the delivery point may be at the head of a watercourse. The system should have in-built incentives for encouraging larger participation of the FO in the distribution of water (Box 5.1);

(e) determine basic water rights, in coordination with FO, at the delivery point based on the following criteria:

- The volume of water based on the approved water allowance at the watercourse head and the designed capacity factor for the distributary will form the lower bound for the water right.

- The volume estimated, based on an average capacity factor during the post Tarbela period, will form the upper bound.

- In determining actual water rights, consideration would be given to: (i) soil and groundwater conditions; (ii) delivery losses within the FO area; (iii) land distribution/farm size within the FO; and (iv) location of the delivery point.

- Specific water rights would be negotiated between FOs and PUs, and approved/registered by the Provincial Regulatory Commission (PRC).

- Following allocation of surface water property rights, groundwater rights would be allocated.

(f) procure water from the PWA as available (in addition to the basic water rights) for sale to FOs; similarly, arrange sale of excess water to other PUs; facilitate trading among FOs (for which PU may charge a transaction fee);

(g) development and maintenance of field drains in (and connecting drains from) the FO areas to provincial drainage system, as contracted for by the PWA or the FOs and;

1. Drainage cost should also be shared by the industries which dispose their effluent into the drainage systems. Similarly, cost of flood protection and management has to be shared by all beneficiaries.

2. At the design stage it is assumed that when operational the distributary will run full—that is all watercourses on the distributary will draw their authorized water allowance. The capacity factor determines the number of days the distributary will run e.g. 0.8 in Rabi means that it will run for 144 days. The guidelines require that a distributary should operated for a block of days (at least 8 days) to ensure that all users on a watercourse receive their share and the losses are minimized.
(h) initiate commercial investments in system development to increase the water use efficiency, and provide fee based technical assistance to FOs in O&M of irrigation/drainage systems.

5.10 Farmer Organizations (FOs) To realize full potential of water markets, it is essential to allow maximum flexibility and control at the highest possible level in the system to the buyers and sellers of water. While it is prohibitively complex and costly for a public agency to arrange sale of water among individual users towards the lower end of the system, it is manageable by farmers. Formation of FOs, initially at the distributary/minor level would reduce the O&M burden of the public sector, enhance farmer participation in the distribution of water, and provide a market to make the true value of water transparent (chapter 3). The FOs would likely be cooperatives, and thus subject to oversight and regulation by provincial government agencies responsible for cooperatives. This will require development of appropriate specialized enabling legislation in most provinces.

5.11 The main functions of an FO will be to:

(a) determine a suitable delivery point to receive supplies from the PU, assess basic water rights at this point, and determine the share of each FO member;

(b) distribute water among its members, facilitate trade of water among its members;

(c) estimate and forecast water needs for the FO area and negotiate with the PU to acquire incremental water or arrange sale of excess water to another FO or PU;

(d) carry out O&M of both the irrigation and the drainage systems within the FO area;

(e) plan and develop the irrigation and drainage system within the FO area. This may consist of improving the distributary/minor, installing control structures to make the system flexible for trading among FO members, installation of meter flumes or other suitable water measuring devices for water accounting, re-design of watercourses and their layout, layout of farm land, on-farm drainage and connections to the PU’s drainage system;

(f) development of groundwater to meet water needs;

(g) estimate total O&M cost including PU charges, collection of water charges or other fees from its members, and payments to the PU.

5.12 Farmer Organizations—Long-run Development: At present, development of FOs in Pakistan is inadequate to support operation of more than a watercourse. Even at this level, despite substantial effort by the Bank, results have fallen well short of desires. As a result, PUs are a necessary interim arrangement. However, the functional structure of a PU should not differ markedly, regardless of who controls it, and so does not impede eventual takeover by the FOs and other local groups with a valid interest in area water resource management. As the FOs expand from the watercourse level, through amalgamation at the distributary and minor levels and through a federation to the entire canal command, they are expected to have more involvement in the work of the PU through greater representation on its board of and more cohesion in their policy stances. At this stage, formation of long-run business policy should be well within their capability. In addition, the FO federation would be expected to concern itself with rationalization of other productivity-related agricultural matters, such as land consolidation and technology transfer.
Transition Arrangements

5.13 **Institution Building: Phase I:** The overall structure outlined in this section will require adjustments to suite varying conditions of the different canal command areas. A phased approach is therefore desirable and several steps are required to enact new institutional arrangements. The first is to develop legislation, and issue administrative orders and notifications, allowing formation of PUs, FOs, water property rights, and water markets. The next step is to define the structure of a PU and the PRC. Because the new institutional structure may be readily introduced through a series of development projects, it is very important to establish a link with the Annual Development Program (ADP). The transition will start by selecting one of 43 canal commands of IBIS as a pilot project under the ADP. Proposed allocations in the Eight Five Year Plan for the Irrigation System Rehabilitation Program, On-farm Water Management Program and drainage can be used for enabling the new institutional structure in the selected area. Transition phases are shown in Table 5.1 in schematic form.

5.14 After forming the PU, the control of irrigation and drainage in the project area will be transferred to PU. During transition, the old and new systems will run in parallel, but with built in incentives to move towards the new system (Box 5.1). The selection of the project and formation of the PU will be announced to the farmers and they will be encouraged to form FOs. In the beginning, considerable assistance will be required for the farmers to form FOs and prepare them for taking over responsibilities. These services could be provided to them through consulting firms or NGOs. The technical assistance wing of the PU would assist in arranging such services. In areas where the FOs are ready for handling bulk water deliveries from the PU on a volumetric basis, these will be switched to the new system. In the rest of the area, the present system will continue with revised crop-based charges to recover full O&M costs.

**Box 5.1 Incentives for Moving to the New System**

There are several incentives for farmers to switch to the new system. It guarantees reliable supply of a minimum amount of water determined as the basic right for the FO area and offers the possibility of acquiring more water through purchases. At the mature stage of the system, most FOs would be able to plan ahead for such purchases and, therefore, total availability of water will be known in advance with a reasonable certainty. This will allow farmers to do advance crop planning and coordinate application of non-water inputs. Water charges will be less than under the old system, because part of the O&M will be carried out by the farmers themselves more efficiently than public institutions. More than 20 percent of the losses occur in the distributaries and minors and about 60 percent in watercourse commands. Recovery of these losses by the FOs would expand their water supply considerably, especially in saline areas. The FOs would receive assistance from the PU/Government in improving their system. Lastly, the new system will allow farmers to manage their own affairs, adopt a distribution pattern they prefer, and generate greater output and income.

5.15 The PU will prepare a water budget and distribution schedule for the command. It will define new rules of warabandi, which will include watercourse losses, in determining time allocation for each farmer. Farmers on a watercourse may continue with the "kacha warabandi". However, if a dispute arises, the PU will intervene in that watercourse command and fix "new pakka warabandi" (which will

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1. Mutually agreed rotational schedule for irrigation deliveries on a watercourse.

2. "Pakka Warabandi" is a fixed rotational schedule of irrigation deliveries.
account for losses in the watercourses). As the PU will not be responsible for enforcing the warabandi. If a dispute arises the arbitration wing of the PRC will adjudicate and its decision will be final. Users who do not pay water charges will be excluded from the warabandi and if nonpayment continues outlets will be closed.

5.16 The PU will estimate O&M costs and establish water charges according to the present system (by crop) and these charges will be approved by the regulatory commission. If the Government wishes to phase increases in PU’s water charges, then the difference must be met by the Government. To recover O&M cost from an FO area, the PU will determine O&M cost of delivering of water at different points in the system and develop a volume-based rate structure which will be approved by PRC.

5.17 After an FO is formed, the PU will work with it to determine an appropriate delivery point. This point should have a control structure for regulating and measuring flows. If such structure does not exist, then the PU will provide it. Based on the approved guidelines by PRC, the PU and FO would estimate basic water rights at the delivery point. The volume, timing, and O&M cost for delivering these basic water rights will then be approved by the PRC.

5.18 **Institution Building: Phase II:** As the FOs are formed, the water balance in the command area may change and the PU will update its water budget. In addition, the PU will assess water losses in the channels in its control and develop plans to recover those losses. Improvement plans will be examined by the PRC (especially in the FGW areas) to determine the extent of the incremental water. The PRC may use, the technical services of agencies, such as WAPDA, for this purpose. Improvements will also be needed to develop operational flexibility and to provide water accounting necessary for efficient operation of the system. At the pilot stage, it will be necessary to develop replicable models. Therefore, the PU will require first class technical assistance services for such designs. As the system develops, the PU may sell any excess water to FOs or to other PUs. Similarly, to meet the demands of FOs, PUs may purchase water from other PUs or PWA (when they are formed at a later stage).

5.19 Different development alternatives for the pilot should be evaluated and designed as part of the project preparation. This should include assisting the PU to design suitable controls to make the system more flexible. While technical solutions exist, the complexity of the problem and importance of arriving at the best solution cannot be overstressed. This makes adequacy of the pilot effort vital. It is also important to design a water measuring and accounting system for the project area. Similarly, consultants should assist in preliminary designs for changing the distributaries and minors that are transferred to FOs. These designs should be finalized and implemented in consultation with the FOs. Drainage needs for the area would be assessed and an overall plan prepared.

5.20 The technical assistance wing of the PU should be assigned to work with the farmers on a distributary/minor to explain the new system and to assist them in forming FOs. Farmers will elect representatives, register the FO, and establish an office and a bank account. With assistance from PUs, TA teams and project consultants, the FO would assess the suitability of existing structures and determine structural improvements required to distribute water efficiently, such as watercourse improvement, control structures, canal improvement, and measuring devices. The FO, assisted by consultants, would prepare plans for the development and financing of these improvements.

5.21 In areas without FOs, the present system of distribution of water will continue except these areas will receive water from the PU instead of PIDs. Water rates will be revised to recover total O&M cost. If a water distribution conflict arises, a revised warabandi (which will include delivery losses) will be implemented.
5.22 During transition, incentive packages would be offered to encourage farmer participation and speed the development of the PU. Costs of such assistance would be fully recovered after a grace period. For the PU, technical assistance would be needed most probably in the form of consulting services, establishment of offices, and improving structures. Similarly, for FOs the incentive package may consist of technical assistance and office establishment to be provided from the development budget. On-farm improvements, (such as lining of the watercourses, provision of flow control and measuring devices, and on-farm drainage improvements) could be financed from the development budget. These would, however, be fully recovered in the form of cash advances, labor contribution, water charges, revenue installments or a combination of these. The FOs would also contribute for improvements above mogha, that is at the distributary or minor level. The recovery level from FOs will be determined on the basis of types of improvements provided, reduction in O&M cost of the PU due to transfer of these facilities, and the paying capacity of the FOs.

5.23 **Development and Expansion: Phase-III:** These would proceed parallel to Phase II. The PU will improve delivery efficiency and expand the water supply by retrieving excessive losses, remodelling the delivery system, development of storage and groundwater development. Similarly, if most of the FOs agree, the PU will plan and develop the drainage system and arrange the disposal of drainage effluent.

5.24 **Final Phase - IV:** This will be the development PUs in the remainder of the canal commands. Lessons learned from the pilot project will be incorporated in the transition of the rest of the area to the new structure. The PWA will be formed after a reasonable number of PUs start functioning.

5.25 **Duration:** Total period required for transition depends on the acceptance of the new institution structure and successful development of the FOs. Although the total period for the four phases is close to 20 years, total transition is expected to be completed in about 15 years as some phases will overlap.

5.26 **Transition Modes:** There are two possible ways to transform the current institutions into the proposed structure. First, a bottom-up approach through a series of pilots projects (at canal command level) in which PUs and FOs will be formed and take over O&M functions of irrigation and drainage system. The changes at the provincial level will be made after the new institutional structure starts functioning satisfactorily in a few canal commands.

5.27 The second option, a top-down approach, is to form the provincial institutions (PWA and PRC) followed by the development of PUs and FOs at the canal command level. This option might bring some efficiency at the top quickly and can also speed up transition.

5.28 The first option is superior, because under this approach: (a) overall disruption will be minimal because, in the beginning, changes will be made only in the pilot areas, while the rest of the system will continue to function as at present; (b) it allows flexibility, a basis for comparison of cost of delivery services and adaption to the local conditions; (c) the system turn over methodology can be improved with the experience gained as the transition proceeds. This experience will also be useful in designing the top level institutions; and (d) it allows the time required to re-orient and train institutions to take over the new functions. It will cause less hard-ship for the staff while ensuring that new institutions are not a bloated replica of the old ones. The transition phasing presented above is developed in view of the bottom-up approach. Steps required for top-down transition will not differ significantly other than development of Phase-IV in the beginning.
Table 5.1 Transition Phasing

<table>
<thead>
<tr>
<th>Phase</th>
<th>Restructuring steps</th>
<th>Responsibility for O&amp;M</th>
<th>Assessment of water charges</th>
<th>Collection of water charges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase-I Formation of Institutions Period 1-2 Years</td>
<td>- Enabling legislation, allowing formation of PUs, FOs, sales of water, establishing water rights and revision of warabandi to include delivery losses.</td>
<td>as presently, i.e. farmers below mogha and PU above mogha.</td>
<td>water rates are crop based but revised to recover full O&amp;M cost of PU.</td>
<td>by PU either directly from farmers or from functioning FOs.</td>
</tr>
<tr>
<td></td>
<td>- Linkage of the Annual Development program with the commercialization of Irrigation and Drainage systems (I&amp;D).</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- a 'pilot' PU is formed converting at least one canal command. At the same time the Provincial Regulatory Commission (PRC) is formed.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- PU announces the revised rules of warabandi in the project area.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- formation of Farmer’s Organizations is encouraged and the TA wing of PU assists FOs in organizing and making technical decisions.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phase</td>
<td>Restructuring steps</td>
<td>Responsibility for O&amp;M</td>
<td>Assessment of water charges</td>
<td>Collection of water charges</td>
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<tr>
<td>---------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
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</tr>
</tbody>
</table>
| Phase - II Institution Building Period 2-3 years | - FOs are formed, water rights of the FOs are determined jointly by the FO and PU, and approved and registered by the Provincial Regulatory Commission. To expedite formation of FOs, incentive packages and TA will be offered to potential FOs.  
- in the FO areas, the system is remodelled wherever necessary and water is delivered to the FOs on volumetric basis at the delivery point. Total deliveries will consist of water rights and purchases from PU or other FOs.  
- in non FO areas the PU will revise the warabandi if a dispute arises.  
- technical wing of PU provides assistance in installation of control structures and measuring devices within its area. | FO is responsible for O&M of the system below the delivery point and PU above. In non FO areas farmers below mogha and PU above mogha. | O&M cost estimated on volumetric basis for the water delivered as water rights and incremental water is delivered at the negotiated price. For water trade among FOs the PU will charge a delivery fee. In non FO areas, water charges are crop based. | PU collects charges from FOs where they are formed and from farmers in non FO areas. |
| Phase - III Development and expansion. Period 3-4 years | - PU improves delivery efficiency and expands the water supply.  
- assessment of drainage needs and development of drainage network if FOs agree. | same as above | same as above. | Same as above. |
| Phase IV Final Phase Period About 10 years | Rest of the canal commands are converted to PUs and PWAs are formed. | Same as above. | Same as above. | Same as above. |
VI. TOWARDS A STRATEGY

Overview

6.1 The overall objective is to establish an efficient, self-sustaining irrigation and drainage system. This involves:

(i) formalizing water markets and individual water property rights;
(ii) restructuring the irrigation water delivery institutions to form PUs around canal command areas;
(iii) actively promoting formation and development of FOs;
(iv) developing allied provincial government agencies; and
(v) strengthening the federal level agencies to better implement their responsibilities.

6.2 In the short run, the strategy requires legislation, followed by successful pilot projects to establish PUs and FOs in the irrigation system and initiate the new institutional structure at the provincial level. At the same time, federal agency capabilities would be strengthened. In the long run, the PU-FO system would be extended to all areas, while consolidating the (provincial) institutional restructuring and maintaining the capabilities of federal agencies. This commercialization of the irrigation and drainage system (that is, handing over responsibility to PUs and FOs) should be supported by the Bank's investment program in irrigation and drainage.

6.3 Commercialization of Pakistan's entire irrigation system will take time. Meanwhile, federal and provincial government agencies should continue planning and developing large projects (such as multi-purpose storage dams, major inter-canal commands and inter-provincial drains), which require considerable lead time. Similarly, the ongoing program of privatizing the groundwater development in fresh areas should continue in commands not covered by PUs. Subsequently, investments in this area will be made by the Federal agencies, PWA, PU and FOs. (Investment options are given in Annex I.)

Short-term Strategy

6.4 At the outset, desirable options for the Federal Government will be to take steps necessary to formally legalize water sales by individuals and establish individual independent water rights. Since a water market is essential to successful restructuring, and must precede any institutional development, this will be a litmus test of government commitment to the strategy. Thereafter, provincial legislation may have to be amended to align it with changed federal legislation, prior to active support for any pilot project.

6.5 Successful pilot projects will be critical. These will require careful screening. Important preconditions for CCA selection are: the pilot must incorporate a complete canal command; absence of extremely negative physical and financial conditions in the CCA; reasonable level of homogeneity of the users; substantial presence of high valued crops (to enhance water market development); and, positive experience with user associations. This ensures that the pilots are not excessively burdened by concerns
which are not central to institutional restructuring, or extreme situations which might complicate formation of the new institutions and PU-FO delivery systems.

6.6 The proposed programs of Irrigation System Rehabilitation (ISRP), OFWM and some of the drainage projects in the Eighth Five Year plan would be at the core of establishing the new institutional structure. The ISRP and OFWM should be redesigned to provide assistance in establishing FOs in the canal commands selected for commercialization. The allocation for these two programs in 1995-98 is about five billion rupees; this appears sufficient for commercializing five average size canal commands, assuming that about 40 percent of OFWM cost would be born by the farmers in the form of labor and/or material at the time of construction.

6.7 The Provincial Regulatory Commission (PRC) would be needed when the pilot PUs are formed. Prior to this, it could provide useful advice to government in legalizing water rights, since it would be responsible for overseeing allocation and subsequent registration of these rights.

6.8 Drainage and flood protection, as public goods, continue to be the responsibility of the public sector. Until the new institutional structure is fully established, present arrangements for providing these services would continue. Ultimately, on-farm drainage will be developed by the FOs, while major drainage systems and effluent disposal facilities will be developed by the PWA or by WAPDA if these are interprovincial.

6.9 At the Federal level, the strategic focus should be on improving quality of the investment program through:

(i) institutional strengthening and streamlining the approval process, and ensuring a match between approvals and financing availability under the ADP;

(ii) prioritizing, through appropriate ranking methodology;

(iii) better project preparation in the areas of technical, economic and financial analyses, and realistic implementation schedules;

(iv) substantive upgrading of the hydrological data collection system through development of a land and water information system;

(v) strengthening implementation of procurement for consultants and contractors;

(vi) improving WAPDA’s capability for monitoring and control of groundwater (Box 6.1), and monitoring and enforcement of water quality in rivers and groundwater aquifers; and

(vii) research to resolve technical issues in the design and construction and O&M of the irrigation and drainage system.

Long-term Strategy

6.10 As pilot projects are implemented, performance should be scrutinized to identify the sources of success or failure. This information should be used to enhance the design and implementation of follow-on CCA projects. As the process expands to include more difficult CCAs, set backs are inevitable. Here
Box 6.1 Monitoring and Control of Groundwater.

WAPDA has an important role in monitoring Pakistan's groundwater resources. In the waterlogged and saline areas, monitoring is necessary for planning and development of drainage projects. In fresh groundwater areas, where over-exploitation is a concern, groundwater levels, extraction, and recharge all need to be monitored. The quality of groundwater must also be monitored for deterioration due to excessive recycling or saline water intrusion. Information will be needed by WAPDA to regulate safe exploitation of groundwater resources. WAPDA can limit tubewell capacity (numbers or sizes) and have the PUs correct the imbalance in the net recharge by increasing the off season recharge to aquifers. The cost of any recharging must be collected from the tubewell owners.

Presently, the SCARP Monitoring Organization (SMO) of WAPDA monitors groundwater levels in SCARP areas only, although WAPDA's responsibility extends to all groundwater. The purpose of monitoring is limited to evaluation of SCARPs performance. The SMO is an old organization using outdated methods in data collection and storage. To implement its country-wide responsibility, WAPDA's capability needs to be enhanced.

6.11 Most of the investment costs of the first five pilot projects will be recovered from FOs during the Ninth Five-Year-Plan, which, combined with the five-year-plan (FYP) allocation would be sufficient for another fifteen canal commands. At this pace the transition would be completed in 15 years by the end of the Tenth FYP. Funding provided for the drainage projects for the development of on-farm and drainage within canal command can also be used in assisting the FOs, and PUs or PWAs to develop drainage facilities, especially in saline areas. Although the Eighth Five-Year-Plan has made allocation for a major storage facility from the first year of the plan, due to time required to start such a large project, it is likely to start late in the plan period. Meanwhile, these funds may be used for the commercialization program, leading to completion in the Ninth Five-Year-Plan.

6.12 When the PRC and the pilot projects are in operation, the Provincial Water Authority should be established. In view of its responsibility to provide water to the PUs-FOs, as well as development and O&M of inter-CCA irrigation and drainage systems, the governing board of the PWA should have substantial representation from both PUs and FOs. This will facilitate any subsequent vertical integration, which is the logical long-run development.

6.13 Again, flexibility in design is necessary for long-run success in a continuing program of enhancement of federal agency capabilities. Both the capabilities and the needs of these agencies will change over time, requiring periodic reassessment to ensure their relevance to the program.

Discussions with the Government

6.14 The green cover draft of this report was discussed extensively with the officials of the Government of Pakistan. In principle, the Government agreed with recommendations of the report and it is willing to implement a few pilot projects as suggested. In addition to formal discussion with the Government, three workshops were organized in Pakistan to disseminate findings of the report. These workshops were attended by federal and provincial agencies involved in the sector, distinguished professionals, water user associations and farmers. The final version of the report takes into account comments and suggestions received from the Government and participants of the workshops. However,
there was disagreement regarding water trading and forming FOs at the distributary level in the short term. These issues are discussed in Box 6.2.

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**Box 6.2 Dissemination Discussion**

1. At a discussion of the green cover report in a workshop held in WAPDA House in Lahore, Pakistan, some participants argued that water trading in Pakistan's irrigation system is infeasible. In their view, since at present water rights are associated with land which is mostly inherited, land and water are inseparable and must remain as originally assigned. They did not see why and how this water could be made available for sale. Also, trading of water along a the distributary canal would result in a variable water flow which would damage canals designed for a specific regime. Concern was also expressed that, if water trading is allowed, a few individuals at the head system may monopolize the water supply.

Trading water at higher levels of the present system is quite complex. These complexities are highlighted in Box 3.4. In the proposed structure, however, basic water rights will be assigned to each beneficiary of the system and these will become their legal property. That water supply has to be guaranteed to each beneficiary for which they will pay O&M cost. The sale of water will be each individual’s decision. The FO will merely facilitate these sales among its members. Presently, such sales take place in almost all watercourses because they are managed by the farmers themselves. At the distributary level, managed by the irrigation authorities, such sales take form of illegal pumping and the revenue is lost out of the system. FO managed distributaries offer a better environment for water trading and ensuring that revenue is captured within the system as well. If water cannot be delivered because of physical constraints, the sale will not take place. If such sales are financially viable, FOs could restructure the system to remove physical constraints. Also, the incremental water by improving the efficiency of the system can be distributed among the FO members as basic right or through sales. The choice lies with FO and its members. Water trading is just an option which can improve the water use efficiency. It is not a precondition for the proposed structure.

2. The Provincial Irrigation Agencies were of the view that FOs should be limited to the watercourse only. While recognizing the importance of organizing the water users, they were of the view that due to low literacy rate, feudal rivalries and inadequate technical capacity farmers cannot manage the system above the watercourses. On the other hand farmer’s representatives were of the view that they can take over the system above watercourses, provided its is rehabilitated to bring it to a suitable condition.

The Bank staff explained that international experience shows that FOs can only be successful if they are given control of water as well as revenue collected from its members through water charges. Also, for an FO to be effective, it should cover a sizeable area (5000 Ha to 20,000 Ha) in order to generate sufficient funds for supporting its institutional setup and technical staff needed for assisting it in O&M of the system. In Pakistan’s irrigation system, water is controlled at the head of the distributary/minor and not at the head of the watercourse. Therefore, in Pakistan the effective FOs can only be organized at the distributary/minor level as they also cover sufficiently large area to support its operation. Some distributaries may be too large covering extremely diverse groups. Therefore, a flexible approach is recommended in developing the FOs and a start should be made with distributaries of a reasonable size.

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6.15 The report has succeeded in highlighting for policy makers and top officials the seriousness of the problem of the irrigation and drainage subsector and generated a continuing discussion among the relevant agencies about how to implement the reform strategy recommended by the report. Restructuring the irrigation sector is particularly difficult as it also requires institution building at the grass root level. Inevitably, full implementation of the strategy will take several successive steps and careful phasing of transformation is critical for success.
Annex I: INVESTMENT OPTIONS IN IRRIGATION AND DRAINAGE SECTOR

1. The Indus Basin Irrigation system is the mainstay of irrigated agriculture in Pakistan. The development efforts in the past were, in approximate order, expansion of command area with construction of barrages and canals, provision of regulation capacity through the reservoirs and inter-river link canals, development of groundwater resources and control of waterlogging and salinity through SCARP projects, private tubewell developments and construction of surface drainage systems and improvements in use of water in the watercourse commands (on-farm). Although declining in volume, investments in the Indus Irrigation system will continue to dominate the overall investments in the subsector. The investment possibilities in the sub-sector are categorized as following:

(a) improving productivity by controlling waterlogging and salinity and protecting lands from flooding. As a public good drainage and flood protection are the responsibility of the Government. Despite "Accelerated Drainage Program", drainage is yet to be provided in the disaster areas (water table less than 5 feet);

(b) efficiency improvements through planning and improved system operation, improving delivery efficiency of canals and watercourses and on-farm water management;

(c) groundwater development in the fresh groundwater areas;

(d) development of storage to expand the water supply and enhance the flexibility of the system to improve operation and enable optimal allocation of water; and

(e) capturing flood water for use in the existing commands and in expansion of the command area.

2. **Drainage:** Flat topography and lack of well defined natural drainage in the Indus Plain create both surface and subsurface drainage problems in the irrigated areas. Seepage from the irrigation network has resulted in high groundwater tables. Under the SCARP program, great effort has been made, since the 1960s, to provide drainage in the irrigated areas and number of large drainage programs are ongoing. Out of the gross canal commanded area of 16.7 Mha, about 6.5 Mha requires drainage, of which about 1.86 Mha are covered under ongoing projects (Annex Box 1). Providing drainage to such a vast area is a large undertaking. Approximately fifty project are planned to cover the entire area requiring drainage and some consisting of several subprojects. Of these, about fifteen are ongoing and rest are new. Approximately 43 drainage schemes are proposed in the Eighth FYP, several of them extending beyond FYP period. It is estimated that about 2.38 Mha area have watertables within 5 feet, such areas are considered as "disaster areas" by the government and are given high priority for drainage. On-going projects cover about 0.85 Mha of disaster area.

3. Provision of drainage is absolutely essential for maintaining the agriculture sector resource base. The disposal of drainage effluent in the rivers, canals and evaporation ponds will not be feasible in the long run. Therefore, an outlet to the sea with link drains from the rest of the basin will be required in the long run to carry highly saline effluent to the sea. Drainage investments are highly viable, with rates of return close to 20 percent. The absence of natural drainage and the continuous nature of the Indus Plain groundwater system requires that all drainage infrastructure be developed in an integrated manner. Independently developed local schemes may be in danger of being overwhelmed by neighboring undrained areas with high water tables and so being ineffective. Due to the large scope of the investments and cross linkages, a balanced development in the drainage sector requires integration of local area drainage needs.

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1. The ERR of SCARP IV was estimated to be 19% and they were 18% in case of SCARP Mardan and Left Bank Outfall Drainage.
Annex Box 1 Pakistan - Scope of Drainage Requirements

<table>
<thead>
<tr>
<th>Gross Area (M ha)</th>
<th>Share (Percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Area</td>
<td>16.67</td>
</tr>
<tr>
<td>Total area requiring drainage</td>
<td>11.46</td>
</tr>
<tr>
<td>Area under completed projects</td>
<td>5.85</td>
</tr>
<tr>
<td>Area requiring drainage in future</td>
<td>6.50</td>
</tr>
<tr>
<td>Under on-going project</td>
<td>1.86</td>
</tr>
<tr>
<td>Remaining area</td>
<td>4.64</td>
</tr>
<tr>
<td>New area</td>
<td>3.75</td>
</tr>
<tr>
<td>Under completed projects requiring Drainage</td>
<td>0.89</td>
</tr>
<tr>
<td>Area with watertable less than 5 feet in April/June 1989-90</td>
<td>2.39</td>
</tr>
<tr>
<td>Under ongoing Projects</td>
<td>0.85</td>
</tr>
<tr>
<td>Under completed Projects requiring Drainage</td>
<td>0.51</td>
</tr>
<tr>
<td>Remaining area</td>
<td>1.03</td>
</tr>
</tbody>
</table>

and such infrastructural developments as the outfall drains for the conveyance of drainage effluent from larger tracts. As described in Chapter 5, On-Farm drainage should be developed by the FOs, while major drainage systems and effluent disposal facilities will be developed by the PWA or by WAPDA if these are of interprovincial nature.

4. Efficiency Improvements: Investments aimed to improve the delivery efficiency of the existing systems have very high returns. The Irrigation Systems Rehabilitation Project (ISRP completed in 1988) designed for the rehabilitation surface irrigation and drainage systems had an ERR of 50 percent. Similarly, the investments in the On-Farm Water Management Projects (OFWM) are very attractive. The estimated ERR for the OFWM-I (completed in 1985) is 29 and 22 percent for the follow-on OFWM-II (completed in 1991) on completion. Based on the success of the earlier projects OFWM-III was launched in 1991. However, the pace of watercourse improvement as carried out under the OFWM projects is quite slow in relation to the total number of watercourses, almost all of which require improvement. By 1990, only 17,715 of the total 107,000 watercourses were improved. Another 7,685 would be improved by OFWM III (by 1995). One of the reasons for the slowness is that Government finances about 70 percent of the cost and is limited by availability of funds and absorptive capacity. This review proposes that OFWM form a larger part of the investment program and that farmers should be fully responsible for the investments, with the PU being responsible only for those aspects which cannot be done by farmers. For example, technological applications such as alignment of the watercourses and possibly land levelling. In general, the technology for improving watercourses is simple, no more complicated than the local methods used in building houses. Along with such improvement, the water users may choose to install gates, water measuring devices or other control structures to regulate flows and to facilitate trading among users. Thus, with some guidance from the TA wing of PUs farmers should be able to carry out these tasks.
5. There are large potential gains from continuing the rehabilitation of surface irrigation and surface drainage systems begun under ISRP I and II. By ensuring a more reliable water supply, which would reduce the risk of crop failure, agricultural production would be increased, and crop losses from rain flooding would be reduced by improving surface drainage. Continued rehabilitation would also provide more equitable irrigation water supply to farmers by increasing deliveries to water deficient chaks, located mainly in the lower reaches of minors and distributaries. At the scheduled completion of ISRP II in 1993, 18,439 km of canals would remain for rehabilitation. Continuation of this activity under a new rehabilitation program is strongly supported, but with considerable changes in the approach. The program should be targeted to the canal commands where the new institutional structure (PU) is to be established and it should assist FOs in improving the distributaries and minors in their control. Another major change must be to improve these channels not just rehabilitate them. Consideration would be given to installation of control structures and water measuring devices to facilitate trading among users.

6. Further improving system operation to make the canal diversions demand-sensitive and capable of re-allocating water among canal commands to optimize overall agriculture production would yield considerable economic benefits. Following, the settlement of the provincial water allocations between the provinces, the age old fear of loosing claim over water in future if not used has been removed. The system operation can and should now be moved towards a more demand-sensitive allocations. This would require enhancing the planning and technical capabilities of the system operators (WAPDA, PWA and PUs) and development of a management information system to facilitate real time operation. Storage capacity plays a crucial role in improving operational efficiency of the system.

7. Fresh Groundwater Development: During last the decade, agricultural growth was led by the development of groundwater. It is an important resource for users in irrigation, and domestic and industrial water supply sectors. Within the canal systems it is often used to supplement surface water supplies during peak demand periods. Large scale development of groundwater started with the SCARP tubewell projects in fresh groundwater areas. Although, the viability of these projects turned out to be very low (RAP estimates about 6 percent ERR), they had a successful demonstration effect in increasing the irrigation supplies for the private sector. The development of groundwater by the private sector on the other hand yields high returns. The SCARP Transition Pilot project (completed in 1992) designed to divest public tubewells in the FGW area by installing private tubewells or transferring their operation to farmers organizations had a completion ERR estimate of 33 percent as compared with the appraisal estimate of 23 percent. Similarly, the ERR of the Private Tubewell Development project to encourage groundwater development in the private sector is estimated to be 18 percent.

8. The number of groundwater tubewells has been increasing consistently (growth rate of about 6 percent annually). In the canal command areas, in aggregate there is potential for further development of groundwater. There is some scope for recovering part of the recharge in moderately saline zones, where lenses of fresh water can be exploited using appropriate technology such as skimming and scavenger wells. Another exploitable source of groundwater is in the ravine areas. Pumping from the aquifer during the low flow period, which is recharged during the floods, the ravine areas offer considerable potential for inter-seasonal transfer. These developments are likely to be undertaken by the PU or PWA as they require technology and conveyance facilities generally not accessible to farmers.

1. Large variations in returns to water by crops, in the delivery efficiency of the canal commands, and in the soil and groundwater conditions within a province are indicative of potential gains to be made by re-allocating water with the provinces. A preliminary analysis by the WSIPs shows that reallocation of only 20% of water and following post Tarbela distribution pattern with the canal capacity constraint can increase value added by more than 2%. Reallocation of water combined with the canal remodelling and reservoir operation will yield much larger benefits.

2. These require technically skilled operators and closely controlled extraction rates.
The groundwater resources outside the Indus Plain are very limited and fully exploited with pronounced mining in some areas.

9. **SCARP Transition Program:** In 1961, WAPDA prepared a ten year program for controlling waterlogging and salinity through the development of groundwater resources named Salinity Control and Reclamation Projects (SCARPs). The entire program consisted of about 31,500 public tubewells (28,000 for supplemental irrigation and 3,500 for drainage only) 7,500 miles of major drainage channels and 25,000 miles of supplementary drains. The program proposed 10 SCARP areas in Punjab and 16 areas in Sindh. Since the implementation of the SCARP projects was progressing slowly, in 1973 GOP adopted an "Accelerated SCARP Program" funded from the federal annual development budget (ADP). Because of the better economic returns, priority was given to locating SCARPs in the areas with groundwater quality suitable for supplemental irrigation, making the drainage a by-product in effect.

10. Under the SCARP projects, about 13,500 tubewells SCARP tubewells (TWs) were installed, of which about 11,000 are in areas with fresh groundwater (FGW) and 2,500 in areas with saline groundwater. About 6,600 FGW SCARP tubewells are in Punjab, 500 in NWFP and 3,900 in Sindh. About 1,800 saline SCARP tubewells are located in Punjab and about 700 in Sindh. The capacities of the SCARP tubewells ranges from 60 to 140 liters per second and they are 40-120 meters deep. In saline groundwater areas, the SCARP TWs provide subsurface drainage relief, whereas in FGW areas they also provide supplementary irrigation water for conjunctive use with canal water. These SCARP TWs had significant impact on controlling waterlogging but their performance declined over time. This declining performance is essentially due to poor management, which resulted in frequent equipment breakdowns, resulting in rising water tables in some areas due to reduced pumping. Although FGW SCARP TWs supply additional water for irrigation, they are not operated according to farmer's irrigation demands, but according to drainage criteria and so are far from demand sensitive.

11. The first attempt to encourage the private tubewell development and transfer the management of SCARP TWs to private sector was initiated under the SCARP Transition Pilot Project (STPP, Cr. 1693-PAK). In STPP (completed in June 1992) private tubewells were installed to replace the SCARP TWs and in some cases the SCARP TWs were transferred to farmer groups. Following STPP, a Second SCARP Transition Project (SSTP) approved in 1991 will privatize about 1,346 STWs in Punjab and 386 STWs in Sindh. The Government is committed to the divestment of all FGW SCARP TWs and this policy is clearly reflected in previous five-year plans and in the draft of Eighth FYP. The transition of STWs should continue in the non PU areas. In the areas where PUs are formed, the SCARP TWs will be taken over by the PU as a participant in groundwater development alongside FOs and private individuals.

12. **Storage and Flood Supplies:** River flows are fully utilized except during the flood period in Kharif. The Water Apportionment Accord of 1991 allocated 117.35 Maf (156.37 Bcm) of water among provinces, an increment of about 12 Maf (15.87 Bcm), and virtually all during Kharif. Supplies above the allocated amount, including flood supplies or from new storage, are shared in the following manner: Punjab and Sindh--37 percent, NWFP 14 percent and Balochistan 12 percent. Incremental water above the present diversions is available only for a short duration--not sufficient to mature a full crop. Canal capacities permitting, a limited quantity can be used for removing water stress in the existing cropped areas. Hence, the utility of the flood water is very marginal unless additional storage is provided in the system to broaden the supply period. Additional storage is also necessary for providing the flexibility needed for demand based operation of the system. More importantly, to maintain the current level of diversions by offsetting storage lost to siltation in Mangla and Tarbela. Several storage sites have been identified in the Indus system. Studies have been carried out for construction of the Kalabagh dam, the Basha dam on the Indus river, the Thal reservoir in the Thal Doab, and raising the existing Mangla dam
on the Jehlum river. Such storage projects generally provide good returns. The rate of return of the Tarbela dam at completion was estimated to be 12.5 percent, despite cost overruns. Similarly, the estimated rate of return for Kalabagh is 18 percent.

13. The designs for one of these sites, Kalabagh dam, have been completed, and the project is ready for implementation. The Kalabagh dam is a multi-purpose project located on the Indus River about 120 miles below Tarbela Dam and sixteen miles upstream from Jinnah barrage and would provide about 7.3 Maf of live storage. The reduced reservoir height (915 feet from sea level instead of 925 feet per current design) would provide a live storage of 6 Maf. Ecological conditions permitting, with Kalabagh canal diversions could be increased to 121.3 Maf annually an increment of 16.3 Maf over the current diversions. A second option is to raise Mangla by 48 feet as provided in the original design. This would provide incremental storage of 3.6 Maf. The river flows may not be sufficient to fill the increased storage capacity in some years. A link canal above to transfer from the Indus to Jehlum above the Rasul Barrage will ensure filling of the reservoir every year. A combination of these two facilities would contribute to incremental diversions of about 6 to 8 Maf on average. Another possibility is to develop storage in Thal Doab along the Chasma-Jehlum link canal. Various investigations have suggested a potential yield of 12 Maf from this reservoir. The project as presently planned would provide 2.1 Maf of live storage capacity. Optimal use of this incremental water would consist of a combination of reduction in water stress and increase in cropping intensity in existing irrigated areas and extension to new areas.

14. The storage projects are usually multipurpose, irrigation, hydropower, flood control, fisheries and recreation. The development of the multipurpose projects, likely to supply water to more than one province, would be coordinated by the Federal Government, with WAPDA providing a lead role. Development of storage systems supplying water to a single province could be developed by the Provincial Water Authority (PWA). The PWA may seek technical assistance from WAPDA for such development. Storage investments will be reviewed by the Indus River Authority for the water availability and compliance with the Provincial Water Accord.

15. Expansion of CCA: Several canal command area expansion projects are proposed by the provinces to use incremental water made available by the Apportionment Accord. They will capture the flood supplies which are for a short period only. Some have poverty alleviation objectives, but sustainability is questionable. There are great difficulties in adapting modern designs of irrigation systems, farm layouts and irrigation practices to the existing systems (which have been operational for more than a century). It is relatively easier to incorporate these in new schemes during design. Also, while they may facilitate the transfer of new technology/practices to existing irrigated areas, it is likely far more cost-effective to address these needs directly. These projects have low returns, as the cost of infrastructure in the new areas is very high and the cropping intensity would be very low. All of these concerns makes them low in priority. Area extension projects are usually provincial projects. The PWA and PUs should jointly develop such projects, with the PUs having primary responsibility for the actual development. At the aggregate provincial level, the PWA will coordinate the development of area extension projects, it will ensure water supply to these projects from the provincial shares and may undertake needed development such as remodelling of link canals etc. These investment are also subject to review and clearance by the Indus River Authority for availability of water.

1. WSIPS estimates N/K ratios of 0.7, 1.0 and 0.4 at 12% for Dajal Branch Extension, Greater Thal Canal, and Rainee Canal project respectively.