The World Bank

Agriculture & Rural Development Working Paper 11

Reforming Governance Systems for Drainage in Pakistan

Toward an Interdisciplinary and Integrated Approach to Agricultural Drainage

Public Disclosure Authorized

ARD
AGRICULTURE AND RURAL DEVELOPMENT

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First printing or web posting: December 2003

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Agriculture & Rural Development Discussion Papers is an informal series produced by the Agriculture & Rural Development Department of the World Bank. These papers raise concepts and issues for discussion in the broader development community and describe ongoing research and/or implementation experiences from the Bank.

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Abbreviations and Acronyms

ADB	Asian Development Bank
AWB	Area water board
CE	Chief engineer
CTWG	Community tubewell group
cusecs	Cubic meter per second
DAS	Drainage advisory service
DBG	Drainage beneficiary group
DLR	Punjab Directorate of Land Reclamation
EC	Electrical conductivity
FESS	Fordwah Eastern Sadiqia (South) Irrigation and Drainage project
FGW	Fresh groundwater area
FO	Farmer organization
GOP	Government of Pakistan
IDA	Irrigation and drainage authority
IWASRI	International Waterlogging and Salinity Research Institute
LBOD	Left bank outfall drain
Mha	Million ha
Mt	Million tons
MONA	Research and experimental station, WAPDA
NWFP	Northwest Frontier Province
NDP	National Drainage Program
NRAP	Netherlands Research Assistance Program
NSDS	National Surface Drainage System
O&M	Operation and maintenance
OECF	Overseas Economic Cooperation Fund (Japan)
OFWM	On-Farm Water Management of provincial agriculture department
PAD	Provincial agriculture department
PD	Project director (Sindh)
PID	Provincial irrigation department
PIDA	Punjab Irrigation and Drainage Authority
PPSGDP	Punjab Private Sector Groundwater Development project
RBOD	Right bank outfall drain
Rs.	Rupies
RSC	Residual sodium carbonate
SAR	Sodium absorption ratio
SCARP	Salinity Control and Reclamation project
SDO	Subdivision officer
SE	Superintending engineer (PID, canal irrigation circles)
SE SCARP	Superintending engineer SCARP
SGW	Saline groundwater area
SIDA	Sindh Irrigation and Drainage Authority
SMO	SCARP monitoring organization
SSTP	Second SCARP transition project
WAPDA	Water and Power Development Authority
WUA	Water users associations
XEN	Executive engineer (PID, canal irrigation circles)

Acknowledgments

This country study was prepared as a contribution to the project—*Agricultural Drainage: Toward an Interdisciplinary and Integrated Approach*, sponsored by the World Bank-Netherlands Partnership Program (BNPP)—Environmental Window for Water Resources Management and the Agricultural and Rural Development Department (ARD) of the World Bank. The activity was managed by Safwat Abdel-Dayem, drainage advisor (ARD) and coordinated by Peter Mollinga, associate professor, Wageningen University. This country study is one of six parallel studies. The other studies are on Bangladesh, Egypt, Indonesia, Mexico, and the Netherlands. Together they will provide the basis for formulating the proposed approach.

The Task Manager and the Coordinator provided general direction for the study and contributed comments on preliminary texts. The country study benefited from the critical comments provided during the special workshop held in Wageningen, the Netherlands, October 23–25, 2002, and attended by Bank staff, country officials and representatives of international organizations, including the Food and Agriculture Organization of the United Nations, (FAO) the International Progamme for Technology and Research in Irrigation and Drainage, (IPTRID), the International Commission for Irrigation and Drainage (ICID), and the International Institute for Land Reclamation and Improvement (ILRI).

This study benefited from research done in 1999 and 2000, when one of the coauthors of this study, Waltina Scheumann, was invited by the International Water Management Institute (IWMI) to Lahore. Many thanks go to all the individuals interviewed during the field study (listed in appendix A) who helped to make it a success. Thanks also got to Dr. Bakhshal Lashari for his contributions in implementing the field program, and to Dr. S.A. Prathapar, who was then director of IWMI, Pakistan Program, and to Zafar Iqbal Mirza and Mehmood ul-Hassan. We also acknowledge the support and assistance with our work given by officials from various organizations, departments, agencies, nongovernmental organizations, as well as by farmers and other civil society members.

Executive Summary

Due to Pakistan's arid to semiarid climate, agriculture, especially in Punjab and Sindh provinces, relies almost completely on surface and groundwater for irrigation purposes. At present, about 16 million ha are under irrigation, using 130 billion m3 of surfacewater and 53 billion m3 of groundwater.

When the irrigation system was constructed in the nineteenth century, it had no drainage infrastructure, which meant that agriculture was increasingly jeopardized by irrigation-induced waterlogging and salinity. Since the 1960s, Pakistan has directed tremendous financial resources toward construction of drainage facilities. From 1960 to 2000, total expenditure for drainage investment was on the order of Rs. 27.7 billion, and ongoing projects were absorbing an additional Rs. 39.5 billion. By 2000, an estimated 7.6 million ha were drained by completed projects; the completion of ongoing projects will add another 4.1 million ha to this area. About 2.32 million landholders have benefited from open drainage infrastructure.

Tubewells were the most frequently adopted technology for controlling salinity and waterlogging, and open drains were the next most common. Canals, distributary canals, and watercourses were lined to save water and reduce drainage requirements. Installation of tile drainage schemes did not start until the 1970s. The use of deep tubewells in fresh and saline groundwater areas reflects a strong emphasis on developing groundwater resources for irrigation. Despite much effort and considerable investment, the severely water logged area has expanded at the country level. The percentage of disaster areas (up to 1.5 m below natural surface level) increased from 9 percent in 1959 to 19 percent in 1999, particularly in Sindh and Baluchistan. At the canal command level, 30 percent of the gross command area suffers from waterlogging, and 14 percent of it is highly waterlogged. In the gross command area, 6 percent is severely affected by salinity and 8 percent moderately.

Drainage infrastructure development did not follow a technically comprehensive plan covering all drainage basins or subbasins. Unlike major works in the Indus Basin project, which have created the world's largest contiguous irrigation system, drainage developed slowly, in isolated projects. Moreover, the Indus Basin lacks major regional outlets for saline effluents, with the exception of the Left Bank Outfall Drain in Sindh. Drainage needs are estimated at nearly 3.7 million ha (in Punjab 1.3 million ha and in Sindh 2.3 million ha).

The development of surface gravity irrigation preceded the development of tubewells, but irrigation in Pakistan today is highly dependent on groundwater, as indicated by the presence of more than 560,000 private shallow tubewells. This state-induced and promoted development has had adverse results. Groundwater tables have declined in some areas; saline groundwater has intruded into fresh groundwater areas; and saline groundwater is being used for irrigation in some locations. Moreover, salts are mobilized by fresh groundwater tubewells—in Punjab 24.7 million tons and another 3.5 million tons in Sindh.

Low-quality water (agricultural effluents, saline groundwater, industrial and municipal wastewater) is recycled within the basin and reused for irrigation, causing secondary salinization and sodification of soils. It is estimated that 6.1 million ha need to be reclaimed.

The organizational landscape for agricultural drainage underwent many changes, in response to felt needs at particular times. A decisive point was the establishment of the federal semiautonomous Water and Power Development Authority (WAPDA) with central authority for planning, designing, and implementing major development projects in the irrigation and drainage sector. Major construction responsibility thus shifted from the provincial irrigation departments to WAPDA leaving them without any significant influence.

Until recently, drainage management was the responsibility of the provincial irrigation departments (PIDs). Adjusting to technical interventions, the PIDs added new units such as the Superintending Engineer (SE) for the Salinity Control and Reclamation projects (SCARPs) and SE Drainage Circles, thus avoiding reorganization of its establishment. Drainage management is strictly separated from irrigation and from flood control, Chief Engineer (CE) Flood. Drainage responsibilities are split up: vertical drainage, SE/PD SCARP; open drainage infrastructure, SE/Project Directors (PD) Drainage Circles, and land reclamation is not the irrigation staff's responsibility but that of the Directorate of Land Reclamation.

Coordination between irrigation and drainage units is almost nil. This works against the implementation of nonstructural means that might have reduced drainable surplus and land reclamation requirements. Lack of coordination impedes synergies between flood control and agricultural drainage, and it favors groundwater extraction whereas improving irrigation management might have curtailed the dependency on groundwater.

Provincial irrigation departments have struggled with open drains designed with lower capacities than required and with a lack of proper outfall conditions. Within the PIDs' domains, maintenance of open drainage infrastructure has been deferred due to inadequate budget allocations as well as nonbudgetary reasons (e.g., low labor productivity and poor staff motivation). Use of main drains by industry and municipalities has increased maintenance requirements and created health risks, which have received little attention. Since PIDs' drainage expenditures are not charged to agricultural beneficiaries, provision of drainage services puts a tremendous burden on the provincial treasuries, in particular the high electricity costs for tubewell operation.

The PIDs' internal procedures for allocating budgets have put the SE Drainage Circles at a disadvantage: It is estimated that overall budget allocations are about 50 percent of overall operation and maintenance (O&M) requirements. Due to increasing establishment costs (e.g., salaries, benefits, operating costs), about half of the O&M budget is not subject to redistributions, and only minor cuts can be made. Since tubewell O&M received priority and consumed about 35 percent of available funding, and canals took up 11 percent, only 4 percent was left for O&M of flood and drainage infrastructure in the 1990s. Allocations to drainage circles are between a third and a half of the circles' demand statements.

In the early 1990s, it was realized that improvements in irrigation management require not only infrastructure interventions, but also institutional-managerial changes, including farmer participation. Recognition that early innovations were unsustainable, prompted donors and national policymakers to seek comprehensive institutional reforms to overcome significant deficits in financing and poor irrigation and drainage system performance.

Under the National Drainage Program (NDP), Pakistan is restructuring its irrigation and drainage sector to provide for a comprehensive, technically integrated drainage system, including outfall conditions. Its institutional component shows a strong emphasis on autonomous, self-financing and self-accounting authorities and demands farmer participation.

The institutional reform package, as envisaged by the National Drainage Program, has been a major challenge to Pakistan's political-administrative system, since it redistributes power and authority among the federal government and the provinces, and affects particularly the PIDs. By 1997, however, almost all province assemblies had approved Provincial Irrigation and Drainage Authority Acts that provided for the creation of provincial irrigation and drainage authorities (IDA), area water boards (AWB) at the canal command level, and farmer organizations at distributary level.

The new drainage strategy takes a comprehensive approach to drainage. Its major objectives are to minimize drainable surplus and to facilitate the evacuation of all saline surplus from the Indus Basin to the Arabian Sea. A Master Drainage Plan would consider surface and tile drainage, groundwater use, salt management, drainage of stormwater, and disposal of treated municipal and industrial effluent. The master plan includes the preparation of a basinwide Drainage Atlas of existing and planned facilities. For planning and management purposes, drainage basin and subbasins are the basic units. Based on the Master Drainage Plan, negotiations for a basinwide, interprovincial Drainage Accord have started among the provinces, the federal government, and WAPDA, including a legal framework for cost sharing and operation.

Only recently has the NDP stimulated the integration of environmental policies into the drainage sector. It has been recognized that drainage causes off-site effects by discharging its effluents into evaporation ponds, water bodies, and water-related ecosystems. For mitigating negative effects, Environmental Impact Assessment has been legally introduced, and an Environmental Management Plan is underway, including strategies on industrial and municipal effluents and the management of wetlands. Issues of concern are the capacity of the environmental agencies in terms of staffing, endowments, and their decisionmaking authority for major infrastructure projects. Equally important are efforts toward controlling water quality for irrigation purposes and groundwater use.

All IDA Acts roughly assign management responsibility for drainage to all levels (IDA, AWB and farmer organizations). However, one issue not yet decided is the management of saline tubewells providing vertical drainage. With respect to the whole array of drainage infrastructure, there is concern about how to see that maintenance receives proper attention. Creating organizational units for drainage management and changing procedures for allocating financial resources seems appropriate. Coordination is needed at nodal points where the areas of jurisdiction of different management units meet, for instance, where open drains managed by farmer organizations discharge into main drains managed by area water boards. In addition, since drainage infrastructure serves nonagricultural users as well, demand and cost contributions have to be coordinated.

Community and private tubewell groups successfully replaced SCARP tubewells in fresh groundwater areas. A major reason is that these tubewells increase water availability. Subsidies and credit facilities promoted group formation, but their long-term sustainability depends on whether transparent water allocation rules are developed and can be enforced; whether recurrent costs can be recovered; and whether rules can be developed and enforced to maintain a safe yield and to prevent saline water intrusion.

In Punjab, establishing drainage beneficiary groups (DBG) at tertiary off-farm open drains has been successful. DBGs comprise farmers that are most affected by waterlogging (“ultimate” beneficiaries). This has been a great incentive for group formation, and for contributions toward the initial investment shares required under the NDP. However, drainage beneficiaries may outnumber the “ultimate” beneficiaries. If only ultimate beneficiaries contribute toward cost, farmers who already suffer from a disadvantage from their location bear the cost, while others enjoy the benefit. In terms of power for collecting charges for drainage or enforcing sanctions, DBGs are weak. The relation between farmer organizations that control irrigation water and DBGs needs clarification.

Group formation and collecting contributions toward investment have been more difficult for the more costly tile drainage schemes. However, success has been achieved in the FESS project areas through social mobilization efforts and favorable credit conditions. The groups have taken over O&M on cost-recovery basis.

Group establishment for managing drainage tubewells has failed. Diffuse hydraulic boundaries makes identification of beneficiaries difficult, and the sheer size of the areas designed to be drained (>500 ha) does not encourage the establishment of groups for O&M. In the case of scavanger wells, there are different groups of benefiting farmers. One group enjoys irrigation water, and another has its land drained. Where interceptor drains are installed, definition of hydraulic boundaries and identification of beneficiaries is equally difficult. Depending on the alignment of the disposal channel, two distinct groups of farmers may benefit, which raises concerns about O&M contributions.

So far, drainage services have been provided free of cost, except for vertical drainage by means of tubewells. In Punjab, tubewell water is charged; in Sindh, a drainage charge is levied. The ongoing reform process plans to recover a significant portion of O&M costs through a drainage cess, which is a sensitive issue. Current composite taxes for major crops including a drainage cess, average 6 percent of net returns and are within the farmers' ability to pay. While farmers are usually aware of the benefits of drainage, they demand improvements in irrigation system management to get their fair share of water, a prerequisite for realizing benefits from drainage. They claim that every effort must be made to prevent malpractices in cess collection.

Lessons Learned and Recommendations

The Pakistan case shows that the long-lasting failure to provide technically comprehensive drainage systems has had high costs for the national economy in terms of land losses, yield reductions, and loss of income opportunities. Recycling low-quality water within the basin and using it for irrigation has caused secondary salinization and sodification of soils, increasing the cost of land reclamation. Despite this disappointing picture, there are some success stories as, for example, in the Fordwah Eastern Sadiqia (South) Irrigation and Drainage project and in the Drainage IV project areas where drainage facilities were installed to the benefit of many small farmers.

The drainage technology applied for decades—deep SCARP tubewells—proved unsustainable both for financial reasons and for maintaining a safe yield in the aquifers. Except for the distinction between fresh and saline groundwater areas (i.e., whether water can or cannot be used for irrigation), interventions followed no comprehensive plan and were implemented in isolated projects without major regional outlets to dispose of saline effluents. Investment needs are high, and nonstructural means—managerial and economic—should be applied to reduce the drainable surplus.

Meanwhile, the Pakistan's policy is moving toward Integrated Water Resources Management, considering surface and groundwater, salt management, agricultural drainage and drainage of stormwater, disposal of municipal and industrial effluents, and water quality control. Planning and management will rely on major drainage basins, or subbasins as basic units, in a design that accommodates both groundwater management needs and irrigation canal command areas. The increasing complexity of tasks requires a sound knowledge base and close links between research institutes and decisionmaking units.

Putting institutional arrangements into place to facilitate the integrated management of water resources is the most challenging task. The evolution of effective management structures with professional skills for drainage depends on the overall progress in creating the new institutions envisaged in the Provincial Irrigation and Drainage Acts. This includes establishing units for drainage management and introducing transparent procedures for generating and allocating financial resources for drainage management.

A uniform cess per area irrigated per season would be advantageous in terms of assessment and billing. In addition, a certain amount may be levied on all farmers who use irrigation water. Seepage from their link canals, for example, significantly contributes to high groundwater levels, and transporting water over long distances creates costs, while farmers benefit from water obtained somewhere else. Since drainage networks serve multiple purposes, it might be useful to define a share to be recovered from the direct beneficiaries (farmers, industry, municipalities), and the share federal and provincial governments will contribute to provide local public goods (e.g., flood control, protection of human lives and assets, improved health conditions). If considered socially desirable, small holdings could get reductions.

Participation in drainage management at micro level, for example, tile drainage schemes and tertiary drains, has remained a difficult task, and results are not unequivocal. Drainage beneficiary groups at tertiary drains can be replicated in similar situations but need support in planning, designing, and constructing drains and facilitating credit conditions. DBGs can be formed at tile drainage schemes if initial shares in investment are within the farmers' ability to pay and if the units transferred are operating. Attempts to transfer the management of drainage tubewells, scavanger wells, and interceptor drains have been most troublesome.

However, where drainage beneficiary groups can be established, their relation to other farmers benefiting from drainage infrastructure requires attention, and conflicts over contributions toward O&M may only be settled by farmer organizations. Since DBGs are established as organizations separate from irrigation management, they are weak in terms of power and authority (collection of charges, enforcing sanctions) compared to irrigation organizations, which control the important input—irrigation water. Benefits from drainage schemes can be realized only if water supply is guaranteed, which creates an urgent need to link drainage management with irrigation system management. In addition, coordination between DBGs, either on open or tile drainage schemes, and the organizations responsible for managing the next level of drainage infrastructure has been problematic. Again, farmer organizations at distributary command level and area water boards at the canal command level would be the ultimate organizations that coordinate and supervise drainage management, and coordinate with nonagricultural stakeholders based on legal regulations.

1. Introduction

Pakistan has the largest integrated irrigation network in the world. It supplies water to 16 million ha, providing income for about four million private farmers. Ever since the introduction of the gravity flow irrigation system in the Indus Basin, groundwater tables and salinity have been rising as a result of seepage of canal water, inefficient irrigation practices, heavy rains during the monsoon season, and flat topography, with only small gradient for natural drainage. In the absence of adequate artificial drainage infrastructure, waterlogging and salinity seriously have impaired agricultural productivity, resulting in an estimated 25 percent loss in crop production. The government has responded by installing deep tubewells under the Salinity Control and Reclamation projects (SCARP), constructing surface drains and tile drainage schemes, and lining irrigation infrastructure.

In the beginning, these drainage interventions reduced the negative effects, but the initial success was upset because maintenance in main and tributary surface drains was deferred, operation and maintenance of SCARP tubewells was poor, and reclamation activities on degraded land were limited. However, investments in drainage systems are still inadequate and undertaken in isolated projects. Moreover, policies have adequately responded to emerging problems such as serious flood events, secondary salinization and sodification of soils caused by the use of low-quality water; accumulation of incoming salts in the Indus Basin and mobilization of additional salts from groundwater use; overuse and depletion of groundwater resources, and the emerging negative effects on natural water bodies and water-related ecosystems.

The assumption underlying this study is that the particular multilevel and multiorganizational institutional arrangement in place for water resources management in general, and for agricultural drainage in particular, has been a constraint on providing effective solutions to the issues mentioned above. Prior to institutional reforms, the institutional setting of Pakistan's irrigation and drainage sector was centralized. Planning, design, and construction were done at the federal level (Water and Power Development Authority), while irrigation and drainage management was the provincial irrigation departments' responsibility. Departmental units dealing with flood control, maintenance of open drains, operation and maintenance of SCARP tubewells, land reclamation activities, and irrigation rarely coordinated their activities. Neither federal nor provincial authorities or agencies were accountable to the farming community, and performance was of little importance to the irrigation and drainage managers. Coordination between and within public administrations was not happening because of bureaucratic rivalries and the costs entailed in coordination. There was neither a coherent political strategy nor appropriate modes and forums for resolving conflicting objectives and coordinating responses to new challenges. This would have required costly restructuring with potential losses for parts of the establishment. In addition, the administrative hierarchies of the public irrigation departments have long chains of communication and decisionmaking that cause losses of information leading to difficulties in control (Scheumann 1997: 211–22).

Political decisionmakers gained access to external funds for constructing new projects, and scarce resources were allocated to new investments. Increasing the supply of water through new investments (SCARP, lining of irrigation infrastructure) seems to have been politically more convenient than investing in maintenance and restructuring departmental units. Decisions to develop new water resources met with water users' preferences and may have resulted from their lobbying policymakers into uneconomic decisions. WAPDA's ability to convince the government of the desirability of drainage investments had little to do with performance because management was separated from project planning and implementation.

Poor performance in the irrigation and drainage sector led to the design of new institutions under the National Drainage Program: The federal Water and Power Development Authority with its Water Wing has been reoriented away from intra-provincial construction toward a wider spectrum of interprovincial functions. Provincial Irrigation Departments are transformed into autonomous provincial irrigation and drainage authorities (IDA) with responsibility for intra-provincial aspects. Self-accounting area water boards operate and maintain irrigation and drainage systems at canal command level. Farmer organizations operate and maintain irrigation and drainage systems within distributary, minor command areas.

Highlighting crucial issues, the study discusses whether deficits characterizing the first institutional arrangement (until 1997 with WAPDA and PIDs) are translated into institutional changes to address drainage issues effectively (since 1997 with IDAs, AWB and farmer organizations). The study reviews how drainage will become part of the new institutional setting. It discusses, in particular, the assignment of management tasks, the financing of recurrent drainage costs, and the relation between irrigation system management and drainage.

Prior to, and under, the institutional reform as envisaged by the National Drainage Program (NDP), participatory approaches to drainage investment and drainage management have been developed that provide an opportunity for assessing whether these approaches are viable and sustainable and might be replicated. Drainage beneficiary groups were established at tertiary off-farm drains and tile-cum-sump drainage schemes, Community tubewell groups were formed in fresh groundwater zones, and farmer organizations are legally assigned responsibility for drainage systems within their command area. The case study evaluates supportive, facilitating conditions for farmers groups to participate in drainage investment and management, coordination of action at crucial interfaces, their organizational structure and representative system, the authority assigned, and their actual power.

2. Agriculture and Drainage Development

Pakistan has a geographical area of about 790,000 square kilometers (79 million ha). It lies between 24 to 37 degree north latitude and 61 to 76 degree east longitude. The country is bordered by Iran in the west, Afghanistan in the northwest, and India in the east. The total area of the Indus Basin (figure 1) is 547,000 square kilometers constituting 57 percent plains and 43 percent mountains. Pakistan has four provinces: Punjab, Sindh, Northwest Frontier Province (NWFP), and Baluchistan.

Pakistan's population of 130 million (1998) is growing at an annual rate of about 2.8 percent. The urban-rural population break-down reveals that the share of rural population has declined by 4.2 percent in the past two decades, from 71.7 percent in 1981 to 67.5 percent in 1998. The share of the urban population has thus increased by 4.2 percent, from 28.3 percent in 1981 to 32.5 percent in 1998. Every third person now lives in cities or towns.

Annual per capita income is US$427. More than 30 percent of the population has incomes below the poverty line. Agriculture contributes about 25 percent to gross domestic product, employing about 44 percent of the labor force. Irrigated agriculture produces more than 90 percent of the total agricultural product and about 70 percent of total foreign exchange earnings through manufactured, semimanufactured, and raw material (Govt. of Pakistan, Economic Advisor's Wing, Finance Division 2001–2002: 11–25).

Figure 1 The Indus Basin, Pakistan

Source: www.dams.org/images/maps/map_tarbela_bw.htm

Agriculture and Irrigation in Pakistan

Pakistan's agricultural sector, particularly in the provinces of Punjab and Sindh, relies almost completely on surface and groundwater for irrigation due to its arid to semiarid climate. Irrigation is considered essential to maintain food production. Official figures reveal that the cultivated area amounts to 16.56 million ha out of which 15.73 million ha are irrigated, mostly with surfacewater resources, while groundwater contributes an estimated 40 percent of the water supplies. The provincial distribution of irrigated area is 8.58 million ha in Punjab, 5.39 million ha in Sindh, 0.33 million ha in Baluchistan and 0.34 million ha in NWFP [ADB and Ministry of Water and Power, Office of the Chief Engineering Advisor, Chairman Federal Flood Commission 2001: 4.2.1(a)].

For an estimated population of 173 million by 2010 and 220 million by 2025, additional water will be required to meet food and fiber requirements, drinking water, and the fodder and drinking demand of more than 60 million livestock 2025. While developing additional water is constrained, improved management of irrigation and drainage systems have the potential to increase agricultural production.

Out of the total of 4.07 million privately managed farms in the country, 2.23 million (55 percent) are operated by owners, 0.79 million (19 percent) by owners and tenants, and the remaining 1.05 million (26 percent) are operated by tenants only. Sindh has the largest number of farms cultivated by tenants. In

NWFP and Baluchistan, the largest farms are cultivated by owners. In Punjab, farms cultivated by owners are 55 percent, and those managed by owners and tenants, and tenants only are nearly the same. The average farm size varies from 0.3 to more than 122.5 ha. Out of 3.76 million farms, about 68 percent are smaller than 6.1 ha (appendix C. table C1).

There are two crop seasons, namely *kharif*, with the sowing season in April–June and harvesting during October–December, and *rabi*, which begins in October–December and ends in April–May. Rice, sugarcane, cotton, and maize are kharif crops; wheat, gram, tobacco, rape seed, barley, and mustard, rabi crops. Major crops are wheat, rice, cotton and sugarcane.

Pakistan's irrigation system is the largest integrated irrigation network in the world. The system is fed by the waters of the Indus river and its tributaries. From 1947 onward, Pakistan implemented the Indus Basin Replacement Works Project which brought about 16 million ha under irrigation. The salient features of the system are three major storage reservoirs—Tarbela and Chashma on the Indus river and Mangla on the Jhelum river—19 barrages, 12 inter river link canals, 43 independent irrigation canal commands, and more than 4,000 distributaries and minors and 107,000 watercourses. The length of canals totals 61,000 kilometers (km). Watercourses, farm channels, and field ditches cover another 1.6 million km. The flows to the Indus are from Himalayan glaciers and snow melt, as well as from rainfall outside the Indus Plain. River waters is diverted into off-taking canals through *barrages*, which are gated diversion weirs. The main canals deliver water to branch canals, distributaries, and minors; the watercourses get their share of water through outlets.

According to the Indus Water Treaty signed between Pakistan and India in 1960, the flows of three main rivers are available to Pakistan—the Indus, Jhelum, and Chenab rivers (the Western rivers). India has exclusive rights to the Ravi, Beas, and Sutlej rivers (the Eastern rivers). The Western rivers have a combined average annual discharge of about 178 billion billion m^3 in 1976–2000. Nearly half of this discharge flows in the Indus river, the remaining coming from the other rivers. The system draws an average of 130.7 billion m^3 of surfacewater each year for irrigation, supplemented by an annual groundwater withdrawal of some 53 billion m^3. The average volume of water available at the farm level is 379 mm/ha.

The Indus plains are underlain mainly by predominantly sandy alluvium to a considerable depth, constituting a highly transmissible, essentially unconfined aquifer system. The irrigated lands of 5.7 million ha are underlain by fresh groundwater (less than 1,000 ppm), about 2 million ha by moderately saline (1,000–3,000 ppm) and 8.5 million ha highly saline groundwater. In Punjab province, most groundwater is fresh with the exception of patches with saline groundwater in the centers of the lower parts of the interfluviums. In Sindh, groundwater supplies are highly saline except along a narrow strip along the Indus river. With the extension of irrigation facilities and the construction of a large network of unlined canals, a major source of recharge to groundwater was added without contemporary drainage facilities. This forced the hydrologic system to a new equilibrium through raising the subsoil water levels close to the land surface with the emerging problem of waterlogging and salinity. An estimated 6 percent of the gross command area is severely affected by salinity, and about 8 percent is affected moderately. About 30 percent of the gross canal commands suffer from waterlogging, and 14 percent are highly waterlogged (Ul-Haq 1998: 93 and tables 1 and 2). Major factors contributing to waterlogging are seepage from canals, distributaries, and watercourses, irrigation of fields, areas inundated during floods, and areas holding rainwater (Govt. of Pakistan, Ministry of Water and Power 2000a: 14).

At present only 27 percent of the annual salt inflow of 33 million tons (Mt) of salts brought in by the Indus and its tributaries are washed out of the system. Of the incoming salts, about 24 Mt are retained in the Indus Basin, 13.6 Mt in Punjab, and 10.4 Mt in Sindh. As surfacewater for irrigation is becoming scarce, farmers increasingly tap into groundwater, a practice that can further degrade land through secondary salinization. At present, about 24.7 Mt of salts are mobilized in Punjab by fresh groundwater tubewells and another 3.5 Mt of salts are mobilized by tubewells in Sindh, annually (ADB; Ministry of Water and Power, Office of the Chief Engineering Advisor, Chairman Federal Flood Commission 2001: 3). The total annual saline drainage effluent is anticipated to be 13.2 billion m^3 of which 1.7 billion m^3 are disposed of into canals, 2.9 billion m^3 into rivers, 1.4 billion m^3 into evaporation ponds, and 7.2 billion m^3 into the sea. Apart from the Left Bank Outfall Drain (LBOD), almost all drainage effluent is recycled within the irrigation system while some is disposed off into e.g. lakes and depressions.

Table 1 Extent of waterlogging (in 1,000 ha)

Province	*0–5 feet (152 cm) water table depth*		*0–10 feet (305 cm) water table depth*	
	June 1999	*October 1999*	*June 1999*	*October 1999*
Punjab	619	403	2,511	2,713
Sindh	2,205	3,796	5,066	5,198
NWFP	32	57	184	206
Baluchistan	79	175	205	241
Total	2,935	4,431	7,966	8,358

Note: Water table depth is measured in June indicating depth in the premonsoon season, and in October, the postmonsoon season. The premonsoon seasons tend to be the most stable periods for comparing water tables from year to year, while postmonsoon water table levels have greater variations because of changing rainfall patterns. Two criteria (0–5 feet, 0–10 feet) are chosen for planning purposes to delineate "disaster areas."

Source: Govt. of Pakistan, Ministry of Food, Agriculture and Livestock, Food, Agriculture and Livestock Division (Economic Wing) 2000–01: 125.

Table 2 Extent of saline and sodic soils (in 1,000 ha)

Property	*Punjab*	*Sindh*	*NWFP*	*Baluchistan*	*Pakistan*
Slightly saline, saline-sodic[a]	472.4	118.1	5.2	3.0	598.7
Moderately saline–saline-sodic					
Gypsi-ferous	14.0	67.7	-	45.2	126.9
Nongypsi-ferous	790.8	257.0	25.7	29.4	1,102.9
Severely saline–saline-sodic					
Gypsi-ferous	140.6	990.5	-	100.7	1,231.8
Nongypsi-ferous	597.7	182.6	8.7	364.0	1,153.0
Very severely saline–saline-sodic					
Gypsi-ferous	122.0	114.0	-	90.8	326.8
Nongypsi-ferous	530.0	379.7	8.9	714.8	1,633.4
Total	2,667.5	2,109.6	48.5	1,347.9	6,173.5

Note: The extent is estimated for an area of about 20.6 Mha in Punjab, 9.2 Mha in Sindh, 9.1 Mha in NWFP, and 30.5 Mha in Baluchistan.

a. Includes soils having mainly surface or patchy salinity and sodicity.

Source: Govt. of Pakistan, Ministry of Food, Agriculture and Livestock, Food, Agriculture and Livestock Division (Economic Wing) 2000–01: 126.

Drainage Infrastructure Development

Agricultural drainage interventions in the arid-semiarid climate of Pakistan serves two objectives: It is a means of combating irrigation-induced waterlogging and salinity and evacuating rainwater during storms and monsoon seasons to the benefit of the farming community and rural residents.

When the huge irrigation system was constructed during the nineteenth century, it had no drainage infrastructure. Due to the flat topography and seepage from the irrigation network, groundwater levels started to rise at an alarming rate. This evolution was exacerbated by the obstruction of natural drainage lines caused by the development of railways, a network of roads, and embankments (Ul-Haq 1998: 86). The threat of waterlogging was recognized soon after the introduction of perennial irrigation in the Indus Plain. Beginning in 1870, observation wells were established in the areas irrigated, and biannual observations were adopted to monitor the effect of irrigation activities on groundwater levels. This network was progressively extended to new areas brought under irrigation later on (Shaikh 1992). The need for drainage was realized first in 1918. Construction of storm-cum-seepage drainage infrastructure started in 1932 in the plain between the Chenab, Ravi, and Jehlum rivers and up to the 1950s, various measures were undertaken but proved to be ineffective. (box 1 and appendix B).

In the 1950s, waterlogging and the associated salinization of soils became widespread, with an annual rate of water table rise between 0.15 and 0.6 m, affecting 30 to 40 percent of the irrigated areas. Then, the newly established Water and Power Development Authority engaged a number of foreign consulting firms to carry out investigations and prepare plans for agricultural development including strategies for eradicating waterlogging and salinity. The consultants[1] all recommended first the installation of tubewells in fresh and saline groundwater areas and then the construction of surface and tile drains and the remodeling of canals to provide additional water for leaching saline soils. Extensive pumping of groundwater would not only capture the whole recharge but also mine the aquifer so as to lower the water table in saline and nonsaline areas.

There was a common understanding that the SCARP tubewells were the most effective means. Their objectives were to eliminate waterlogging, increase average crop intensity to 150 percent, and reclaim salt-affected lands by providing additional water for leaching of salts.

The first key document to pave the way for the installation of large public tubewells during the 1970s was the Indus Special Study of 1966 (Quarry 2001: 43). The study also expressed concern about water losses from seepage in irrigation channels, but this attracted little attention. Instead, it was decided to develop new sources of water to satisfy water demand during the rabi cropping season and to expand the delivery system to increase water availability during the kharif season. Large public tubewells would perfectly solve the water constraint and combat waterlogging.

On a large scale, the SCARP Program was initiated in the past years of the first Five Year Plan (1955–60) and continued under the second Five Year Plan (1960–65) which, initially, had focused on surface drainage construction. However, due to paucity of funds, allocations to SCARPs were reduced during the subsequent Five Year Plans and physical targets lagged behind the implementation schedule. Still, installation of SCARP tubewells received high priority until the 1990s, although its physical achievements met with partial success. The SCARP tubewells lowered the water table below 1.5 m in 2 million ha and below 3 m in 4 million ha, thus alleviating waterlogging significantly and also reduced the moderate to highly salt-affected area from 7 million ha to 4.5 million ha. However, initial success was upset because of poor operation and maintenance. The water table started to rise again, and groundwater

[1] Harza Engineering Company International, Tipton and Kalmbach Inc., Hunting Technical Service, Mott MacDonald & Partners, Roger Revelle & Associates.

quality in many SCARP areas deteriorated, causing secondary soil salinization when used and recirculated (Govt. of Pakistan, Ministry of Water and Power 2000a: 8).

When in the late 1960s, a research project sponsored by the U.S. Agency for International Development measured water channel losses, it came up with alarming results. Water losses through seepage from the irrigation network were estimated at about 50 percent. Losses from watercourse heads to tails range between 31 percent and 51 percent, with the greatest losses in the SCARP areas where, in addition, pumped groundwater discharges into watercourses without adjustments or improvements. The public tubewell program of the 1970s had actually increased water losses in the watercourses by increasing the hydraulic gradient between watercourses and water table. These disappointing results caused a slow shift in emphasis from increasing the water supply to reducing seepage losses and to improving efficiency rather than delivery. Only at the end of the 1970s, however, did the Revised Action Program for Irrigated Agriculture emphasize that irrigation organizations should become more effective.

An accelerated program for controlling waterlogging and salinity (1974/75 to 1984/85) was initiated for a period of 10 years by the Planning and Development Division, Government of Pakistan, together with WAPDA and the provincial governments. The program envisaged the installation of tubewells in fresh groundwater areas, tubewells and tile drains in saline groundwater areas, and open drains. It covered 5.7 million ha (3.56 in Punjab, 1.94 in Sindh, 0.19 in NWFP, and 0.02 million ha in Baluchistan). Under financial constraints, it was decided to direct scarce resources to areas with usable groundwater with water table depths between 0 m to 1.5 m in summer only, when the kharif season starts (table 2). However, due to scarce resources, the water table depth could not be stabilized at 3 m (Ahmed and Ali 1986: 71–79).

For the first time, the accelerated program defined nine agroclimatic zones in Pakistan: Northwest Frontier province, Punjab Mixed–Wheat, Punjab Rice–Wheat, Punjab Sugarcane–Wheat, Punjab Cotton–Wheat, Sindh Cotton–Wheat North and South, Sindh Rice–Wheat North and South. Zoning relied on general crop patterns prevailing in most farms and their demand for surfacewater, production potential, availability and quality of groundwater, waterlogging and salinity hazards (Ahmad and Kutcher 1992: 7–16).

In 1979, WAPDA’s Revised Action Program developed strategies for private sector involvement because financing maintenance of public tubewells had become an issue. Since raising water charges has been a politically sensitive issue, private sector participation should be encouraged for drainage and reclamation of saline lands with fresh groundwater underneath.

Since 1976, the newly established On-Farm Water Management Directorate, Provincial Agriculture Department, has been in charge of planning, design, and implementation of On-Farm Water Management (OFWM) projects (Gill and Mushtaq 1998: 37–44 and 117–124; JICA and GOP 1997).[2] Their main components are rehabilitation and reconstruction of earthen watercourses with partial brick lining to increase water delivery and reduce seepage losses; precision land leveling to improve irrigation efficiency; and extension services for on-farm water management through demonstrations and advanced irrigation techniques. At the beginning of the projects, 75 percent of lining costs were born by the government. The response from farmers was positive mainly because of increased water availability. When high demand from farmers started to exceed public financial resources, the government put a percentage ceiling on the total length of watercourses it would finance: 15 percent for watercourses in fresh groundwater areas; 30 percent and more for watercourses in saline areas.

2 The On-Farm Water Management projects started in the mid-1970s with the OFWM Pilot project (USAID-assisted), followed by a great number funded with ADB, IDA, and OECF loans. In Punjab, 17 projects were completed: 18,400 km of watercourses were lined, and earthen improvements on another 95,925 km were carried out.

However, the OFWM projects showed mixed results. Although the Revised Action Program for Irrigated Agriculture focused on saline groundwater areas to slow water table rise, reduce drainage needs and prevent loss of water for irrigation purposes, OFWM staff did not apply technical criteria, and saline areas did not receive priority. Other components such as precise land leveling and improved on-farm techniques were marginal and almost neglected. On-farm water management strategy turned into construction activities at the expense of aspects of on-farm water use. This was partly caused by the World Bank's technical performance indicator, which was closely tied to physical processes rather than to development impacts and institutional progress. It undermined incentives for OFWM staff, and construction progress gained highest priority.

The World Bank conditioned release of subsidies on the formation of water users associations at watercourse level to take over watercourse maintenance. In 1981, the Water Users Association Ordinance was enacted. However, water users associations did not last after completion of construction works because they only were established to implement lining activities (Byrnes 1992). A second shift came with the transfer of public tubewells to the private sector, which started in the period of the seventh Five Year Plan (1988–93) and gained high priority under the Second SCARP transition project (1991–97).

Both initiatives are noteworthy since they brought institutional issues to the fore. Up to this time, development projects in the irrigation and drainage sector were mainly about construction of civil works. Management of resources and of drainage infrastructure was almost neglected. Developing the institutional viability of the major organizations responsible for operation and maintenance—the provincial irrigation department—had received scant attention and the installations' ultimate reliance on the irrigation departments was disregarded.

Box 1 Chronology of strategies and control activities

Canal seepage control

After opening the Upper Chenab Canal, a Drainage Board was set up in 1917–18 in Punjab to address waterlogging along the canals. The board recommended various methods to control canal seepage such as frequent canal closures, lowering of canal water level, and growing of trees along irrigation channels. In the early 1940s, the Rasul Tubewell Scheme was initiated comprising tubewells along the main canals and branches to pump seepage water and feed it into the canals. However, seepage drains along canals did not achieve any significant lowering of water table depth since these could intercept only a very small part of the total infiltration to the groundwater. The strategy was not effective because, due to their location, the tubewells pumped canal water instead of subsoil water.

Lining of canals, distributaries, and watercourses

To reduce seepage, lining of canals was initiated as in Haveli (1937), Thal Main Line Upper (1943), Mojhar Branch (1944–45), Thal Main Line Lower (1950), Bambanwala Ravi Bedian Link (1952), Balloki Suleimanki Link No.1 (1955), Akram Wah, Lined Canal in Sindh (1956), Sidhani Mailsi Bahawal Link (1965), Pehur Canal in NWFP (1980), Chashma Right Bank Canal, Phase I and II (1987), Ghazi Barotha Hydel (1996), and the yet to be undertaken Chashma Right Bank Canal, Phase III (Ahmad 1998: chapter 5C).

Under the Command Water Management projects (starting in 1986), a few distributaries and their minors were lined in all provinces: Pakpattan, Shahkot, Niazbeg and 6-R Hakra in Punjab, Naulakhi-Sehra in Sindh, Lasbela in Baluchistan, and Warsak Lift Channel in NWFP

As seepage losses in watercourses are high, with losses from watercourse head to tail ranging between 30 percent and 50 percent, lining of watercourses started in the mid-1970s with the On-Farm Water Management projects.

Surface drainage

Box 1 Chronology of strategies and control activities

Serious flood hazards in the late 1940s pointed to surface run-off problems (Mustafa and Wescoat 1997; Govt. of Pakistan, Ministry of Water and Power, Office of the Chief Engineering Advisor/Chairman Federal Flood Commission 2002: 2-21–2-23; 2-38), and construction of open surface drains started between 1950 and 1960. The second Five Year Plan (1960–1965) had placed major emphasis on surface drainage, but shifted financial allocations to SCARP projects at the end of the term. Not until the start of the Accelerated Program in the mid-1970s did construction of surface drains regain some importance.

However, it was realized that trapped rain and floodwater had contributed as much to water tables as seepage from irrigation infrastructure. While surface drains working as seepage drains have a limited area of influence, and are effective only in a strip a kilometer wide on either side, during the rainy season they do provide the only mode of quick and effective evacuation of stormwater.

Pilot drainage scheme

The Soil Reclamation Board, established in Punjab on the recommendation of experts from the UN Food and Agriculture Organization, initiated a pilot scheme near Chaurkana in 1954–55, for the installation of 25 tubewells.

Salinity Control and Reclamation projects

Since the 1950s, the Water and Power Development Authority launched 38 Salinity Control and Reclamation projects on the recommendations of foreign consultants (appendix C, table C3).

Tile Drains

Since 1977, tile drainage projects have been implemented on an area of 200,000 ha. The first tile project was the East Khairpur Tile Drainage project (1977), followed by the Mardan SCARP project (1983) in NWFP and the Drainage IV Project (1984–94), Phases I and II in the district of Faisalabad. The Fordwah Eastern Sadiqia South project in Punjab and the LBOD (Sindh) have tile drainage components.

Left Bank Outfall Drain project

The Left Bank Outfall Drain project (1985–97) comprises an outfall drain to dispose saline effluent into the Arabian Sea, surface drains covering the whole area, tile drainage network on 392,000 ha, interceptor drains along selected reaches of irrigation canals, a distribution network to electrify the drainage tubewells and pumps, on-farm water management components including improvement of watercourses and precision land leveling, remodeling of the Nara and Jamrao irrigation systems, and construction of the Chotiari Reservoir and the associated Ranto Canal to provide supplementary irrigation.

The LBOD improved irrigation and drainage conditions in the southeastern districts of Sindh (Nawabshah, Snaghar, and Mirpurkhas), where intensive irrigation caused rising water tables, waterlogging, and soil salinization. The project improved drainage on about 516,500 ha and increased irrigation supplies for about 290,000 ha (ADB 2000).

Fordwah Eastern Sadiqia (South) project

The Fordwah Eastern Sadiqia (South) project (1990–2002) was initiated in one of the poorest parts of Punjab to combat waterlogging and salinity on a gross area of 121,000 ha, where more than 85 percent of the farms are smaller than 10 ha, and 54 percent of them smaller than 5 ha. Canal lining and watercourse improvements have reduced seepage, and surface drains have evacuated stormwater. The waterlogged area has been reduced from nearly 80 percent in 1997 to 24 percent in 2000 (World Bank 2000).

The FESS project combined structural (watercourse lining, open drains) and nonstructural (institutional) elements. Planning, design, and construction was carried out with farmer participation at each stage initially. drainage beneficiary groups were established, and farmers contributed toward initial costs and participate in O&M.

Box 1 Chronology of strategies and control activities

Right Bank Outfall Drain

The RBOD is to provide a means of disposing of effluents. The outfall drain would follow the natural valley located in the west of the right bank and would incorporate the existing Main Nara Valley Drain. Alternative options were discussed, but recently, the Government of Pakistan decided that the RBOD will discharge directly into the sea. The initial estimated expenditure is Rs. 14.0 billion; implementation started recently.

Source: Ahmad (1998) chapter 6.

Table 3 Drainage projects, 1960–2000

Scheme	*Cultivable command area (million ha)*	*Estimated cost (millions of Rs)*	*Tubewells (number)*		*Surface (km)*	*Tile (ha)*
			FGW	*SGW*		
Punjab						
Completed projects						
Tubewell drainage	3.56	10,651.63	8,282	1,976	2,624	—
Surface drainage	0.48	1,036.57	40	—	296	—
Tile drainage	0.63	5,141.70	2,456	—	842	54,008.1
Total	4.81	16,911.49	10,778	1,976	3,762	54,008.1
Ongoing projects						
Tubewell drainage	2.33	3,909.11	7,863	280	281	—
Surface drainage	0.84	14,332.19	—	—	891	1,417.0
Total	3.17	18,241.29	7,863	280	1,172	1,417.0
Sindh						
Completed projects						
Tubewell dra inage	0.79	—	4,437	474	570	—
Surface drainage	1.51	3,914.58	—	—	8,710	—
Tile drainage	0.02	630.03	—	—	—	13,765.18
Total	2.32	7,266.61	4,437	474	9,280	13,765.18
Ongoing projects						
Surface drainage	0.86	35,434.67	—	2,175	1,986	22,267.21
Total	0.86	35,434.67	—	2,175	1,986	22,267.21
NWFP						
Completed projects						
Tubewell drainage	0.27	622.621	491	—	703	—
Tile drainage	0.11	3,927.67	—	—	415	45,217.41
Total	0.38	4,550.29	491	—	1,118	45,217.41
Ongoing projects						
Tile drainage	0.11	6,273.20	—	—	530	—
Total	0.11	6,273.20	—	—	530	—
Baluchistan						
Completed projects						
Surface drainage	0.06	125.51	—	—	332	—
Total	0.06	125.51	—	—	332	—

— Not applicable; FWG Fresh groundwater area; SWG Saline groundwater area

Sources: Compiled from Govt. of Pakistan, Ministry of Water and Power 2001a: 3-14; 3-16; Govt. of Pakistan, Ministry of Water and Power 2000a: 24–27.

Growing Environmental Concerns

Ever since the introduction of the gravity flow irrigation system in the Indus Basin, seepage of canal water and inefficient irrigation practices, together with stormwater and the flat topography with only small gradient available for natural drainage, has caused rising groundwater tables and salinization. These environmental problems were put on the agenda when they seriously curtailed agricultural productivity. The installation of drainage technology, first the SCARP tubewells, later followed by open drainage infrastructure and tile drainage schemes, have been a means of tackling negative effects. They have mitigated some negative environmental effects of irrigation systems on soils (waterlogging, salinity), leading to increased yields and rural incomes.However, negative effects have emerged within irrigation commands and off-site, some of them related to the development and management of drainage.

Mining of Groundwater

Research indicates a high variability of surfacewater actually delivered into distributaries and subsequently into watercourses. According to data collected in selected distributaries and watercourses, outlets to watercourses in tail reaches seldom obtain more than a fraction of their designed, or sanctioned, discharge at watercourse head. Farmers in tail locations get, on average, less than a fifth of what reaches farmers at the head of the distributaries. The frequency of days without canal water at the heads of watercourses increases in the tail reach of the distributary (Kijne and van der Velde 1992: 146–47; Bandaragoda and ur-Rehman 1995: 29). This causes large portions of command areas to depend heavily on water supplies from tubewells. The ratio of groundwater to surface canal water used varies with location, and ranges, for example, in Lagar command between 1.2:1 to 14.7:1, the latter occurring in a tail-end watercourse. It is reasonable to assume that groundwater from public and private tubewells contributes about 70 percent of all water used in agriculture in Farooqabad subdivision. Public tubewells provided, on average, 43 percent of irrigation water available to farmers in rabi and 30 percent of supplies in kharif. Because many public tubewells are dysfunctional and no longer operate at full capacity, it is assumed that they contribute, on average, about 25 percent to irrigation supply.

The concept prevalent in the 1960s that government, by retaining control, could easily coordinate pumping and canal diversions, has failed, because government never achieved control over groundwater pumping. Instead, the demonstration effect of public tubewells, and the subsidies provided, induced a massive boom in private tubewell investment. At present, due to drought and shortage of canal water, there are more than 560,000 private tubewells.

However, shallow tubewells have added to irrigation water supply and have enabled farmers to maintain high cropping intensities and diversified cropping patterns with less drought-tolerant and more water-consuming crops. Shallow tubewells helped to reduce risks caused by the high variability of surfacewater actually delivered into distributaries and subsequently into watercourses. During the past two to three years of drought, farmers have relied more than ever before on groundwater to escape water stress and avoid crop losses at the cost of maintaining a safe yield in the aquifer. The water shortage pressed particularly hard on small farmers. Consequently, more shallow tubewells were installed in fresh groundwater areas, where groundwater tables are declining from overuse as the extraction rate exceeds the replenishment rate. Even in some saline areas, farmers have installed shallow tubewells are mixing saline groundwater with canal water.

Secondary Salinization

Waterlogging and salinity were long regarded as the twin menaces of irrigated agriculture in Pakistan. It was assumed that with the reduction of groundwater table depth and waterlogging, the problem of salinity could largely be solved. However, early observations by the Soil Survey of Pakistan (1977) stated that secondary salinity could occur as a build-up of high sodicity in nonsaline agricultural land irrigated with low-quality tubewell water (Choudhri 1977). In 1989, the Survey of Pakistan discerned the dissociation of waterlogging and salinity:

> The secondary salinity, which is of much greater concern than that akin to waterlogging, is the build-up of high sodicity in first-rate, nonsaline agricultural land caused by irrigation with low-quality tubewell waters. This type of salinity is introduced with the accelerated use of groundwater. The symptoms of the sodicity of soils are widespread, as observed from hardening of topsoil, decrease in rate of infiltration and inadequate seed germination, especially of alkali-sensitive crops (Kijne and van der Velde 1992: 145).

Kijne and Van der Velde (1992) reported that, in many tubewells in the command area of Manawala distributary, groundwater deteriorates toward the tail. Similar data and spatial patterns are indicated for public and private tubewells from head to tail in other distributary command areas. Beg and Lone (1992) investigated quality parameters in 1,900 deep tubewells over a time span of 25 years; they established that overall groundwater quality deteriorates, particularly in residual sodium-content levels (Shah et al. 2001: 14–20). Van Steenbergen and Oliemans found that tubewell densities in areas with marginal groundwater do not substantially differ from those in fresh groundwater areas but that "particularly in many tail reaches, little good quality water is available to mix the marginal quality groundwater" (1997: 99). Even in saline zones, as much as 19 percent of the on-farm water comes from tubewells. Where groundwater of poor quality is used for irrigation, it has caused secondary salinization and sodification of soils. The overall need for land reclamation in Pakistan's irrigated areas is estimated at around 6.1 million ha (Govt. of Pakistan, Ministry of Water and Power 2000a: 30–31; Govt. of Pakistan, Ministry of Water and Power 2000b: 2).

Surfacewater Quality

In the absence of any treatment, the water quality of the Ravi river is most seriously affected due to sewerage from the city of Lahore, and industrial effluent from Kala Shah Kaku industrial estate and other industries that discharge into Deg Nallah and ultimately into the Ravi river (Haider et al. 1999: 5–7; Govt. of Pakistan, Ministry of Water and Power, Office of the Chief Engineering Advisor/Chairman Federal Flood Commission 2002: 5-14–5-17). Since effluents of drains, saline tubewell water, and waters polluted by untreated industrial and municipal sewage are recycled within the system, except in the LBOD area, water quality may become unsuitable for drinking due to toxic substances and for irrigation purposes due to salinity (Ul-Haq 1998: 95–96). During the low flow period in winter (October to April), the disposal of sewage and industrial waste effluent into drains and rivers impairs river water quality. Salinity of the Indus river water at Kotri Barrage would increase from 150–200 ppm in summer to 500–600 ppm in winter. Other data indicate that the quality of river water, even during low flow periods, is good for irrigation and other purposes, although the river carries the all the drainage effluents of NWFP and more than 90 percent of Punjab province including the saline water from drainage tubewells. Water quality of main drains with saline effluents with more than 1,500 ppm is largely diluted. However, the disposal of drainage effluent of southern Punjab requires careful investigation (Govt. of Pakistan, Ministry of Water and Power, Office of the Chief Engineering Advisor, Chairman Federal Flood Commission 2002: chapter 5).

Freshwater Ecosystems and Evaporation Ponds

Pakistan has a diverse range of wetlands covering a total area of about 7.8 million ha (Ul-Haq et al. 1998; Govt. of Pakistan, Ministry of Water and Power, Office of the Chief Engineering Advisor, Chairman Federal Flood Commission 2002: 5-10–5-14).[3] Freshwater ecosystems such as rivers, lakes, wetlands, and

3 See http://www.wetlands.org/RDB/Ramsar_Dir/Pakistan_.htm.

the delta are under serious threat due to, for example, the discharge of drainage effluents, polluted waters, and water extractions. The Indus and its tributaries have declined as wetland habitats as flows have diminished and some tributaries dry up altogether part of the year (Pakistan Drainage Consultants 2002a: A.3; C.1.1). The Larkana Shirkarpurand North Dadu surface drainage project, for instance, is diverted into Hamal and Manchar Lakes in the Sindh province. These lakes of national and international importance as migration routes for birds are exposed to salinity. The accumulation of sediments affects fish production and reduces capacity for flood control. It affects agricultural production and people's livlihoods and has created an environment that is disturbing to migratory bird species (Govt. of Pakistan, Ministry of Water and Power, Office of the Chief Engineering Advisor/Chairman Federal Flood Commission 2002: 5-10–5-14).

The disposal of effluents into manmade evaporation ponds has become hazardous, particularly when rainfall or stormwater inflows cause overtopping or spreading; lateral seepage causes contamination of groundwater and low-lying lands. The highly saline effluent of SCARP VI and FESS is discharged into natural depressions in the Cholistan desert. There, a rise in groundwater tables and soil salinization, observed in adjacent areas, negatively direly affected agriculture in just five years of evaporation pond operations (Alam et al. 2000). The effluents of the Hairdin drainage system enpty into evaporation ponds near the provincial border of Baluchistan and Sindh, severely degradiing thousands of hectares of fertile land.

Minimum in-stream water requirements are not maintained below Kotri Barrage, the last water diversion structure on the Indus river before it discharges into the Arabian Sea. The tidal delta area (620,000 ha), extending from Karachi to Rann of Kutch along the Indian border, is affected by tides and exposed to low tides. About 200 villages with a population of 125,000 are situated in these riverine areas where agriculture and fishing are the mainstays of income. Minimum in-stream water requirements would maintain, in addition to productive uses, riverine and mangrove forests and would prevent sea water intrusion that forces thousands of families to migrate (Govt. of Pakistan, Ministry of Water and Power, Office of the Chief Engineering Advisor, Chairman Federal Flood Commission 2002: 3-8–3-10).

Conclusions

Pakistan has made unique efforts to control waterlogging and salinity and has directed tremendous financial resources toward drainage infrastructure development. From 1960 to 2000, total expenditure for drainage infrastructure investment were on the order of Rs. 27.7 billion plus Rs. 395 billion for projects ongoing at that time (Govt. of Pakistan, Ministry of Water and Power 2001a). During this period, drainage investment was conceptualized to reclaim cultivable command areas: in Punjab, 7.84 million ha; in Sindh, 3.18 million ha; in NWFP, just under 0.50 million ha, and in Baluchistan 0.07 million ha. By 2000, the area drained by completed projects was estimated to cover 7.63 million ha, with another 4.10 million ha that will be drained through ongoing projects. The total area drained by surface drainage infrastructure is estimated at 8.77 million ha. Distribution by province is as follows: Punjab 5.78 million ha; Sindh 2.55 million ha; NWFP 0.37 million ha, and Baluchistan 0.07 million ha. It is said that 2.32 million landholders benefited from these surface schemes (Govt. of Pakistan, Ministry of Water and Power, Office of the Chief Engineering Advisor, Chairman Federal Flood Commission 2002).

Agricultural drainage interventions in the arid-semiarid climate of Pakistan is a means of combating irrigation-induced waterlogging and salinity and evacuating rainwater to the benefit of the farming community and rural residents. The most adopted drainage technology are deep tubewells (12,700 public tubewells in fresh, and 2,500 public tubewells in saline groundwater areas) which gained high priority in the Five Year Plans until the beginning of the 1990s, but could not provide adequate relief. There are over 560,000 private shallow tubewells in fresh groundwater areas, followed by open drains (14,500 km), tile drainage schemes (220,000 ha), and 560 km of interceptor drains (Knegt 2000: 88–89). In Punjab, the early choice of SCARP tubewells shows a strong emphasis on developing additional water for irrigation and leaching purposes. Lining of canals, distributaries, and watercourses was implemented to prevent seepage and save irrigation water.

Drainage infrastructure development responded to critical situations but did not follow a technically comprehensive plan covering major drainage and subdrainage basins. The drainage technologies invented show site and scale specifications (table 4). At present, deep tubewells, main drains, and distributaries cover at least parts of the critical and most affected areas on a large scale, but there is a serious lack of tertiary open drains to connect fields to the main infrastructure. The area requiring drainage is still huge—about 3.75 million ha, distributed by province as follows: Punjab 1.29 million ha; Sindh 2.28 million ha; NWFP 0.09 million ha, and Baluchistan 0.08 million ha. To mitigate negative environmental effects, particularly off-site, planning and implementation of drainage projects would require the application of environmental standards.

Table 4 Drainage typology of Pakistan's arid and semiarid environment

Drainage technology	*Site specification*	*Objectives*
Deep tubewells	Saline groundwater areas	To lower groundwater table depth and reduce waterlogged areas To maintain water table at appropriate depth
Deep tubewells	Fresh groundwater areas	To increase water availability for irrigation To lower groundwater table depth and reduce waterlogged areas
Shallow tubewells	Fresh groundwater areas	To increase water availability for irrigation
Tile drains	Shallow aquifers (groundwater table depth <1.5 m) Areas with brackish groundwater where reuse is problematic	To reduce waterlogged areas Reuse of effluents increases water availability for irrigation
Interceptor drains	Interface saline–fresh groundwater along unlined canals with high seepage	To prevent salt water intrusion into freshwater aquifers To maintain water table at appropriate depth To reuse pumped seepage water
Surface main and tributary drains	Covering, as a rule, many canal command areas	To capture seepage of canals To dispose of excess irrigation water To remove surface flooding from heavy rainfall To dispose of industrial and municipal wastewater
Tertiary open drains	Areas irrigated at watercourse level	To reduce waterlogged areas To dispose of surface run-off and excess irrigation water
Outfall drains	Regional scale	To prevent recycling of agricultural effluents and industrial and municipal wastewater To dispose of effluents outside a basin To maintain a reasonable salt balance
Lining of canals, distributaries, watercourses	Waterlogged and water short areas, favored in saline groundwater areas	To prevent seepage and water losses

Source: Authors' compilation.

Box 2 Drainage profile of Pakistan

- Pakistan has the largest contiguous surface irrigation system in the world, which has no counterpart in drainage.
- Conjunctive use is made of surface and groundwater for irrigation purposes.
- Agricultural drainage in the arid-semiarid climate of Pakistan serves two objectives: it is a means of combating irrigation-induced waterlogging and salinity and evacuating heavy rainfall.
- Drainage investment to cope with waterlogging and salinity was started in the 1950s, using vertical drainage tubewells, scavanger tubewells, interceptor drains, main and tributary open drains, natural watercourses, tile drains-cum-sump schemes, and lining of canals, distributaries, and watercourses.
- Drainage infrastructure is developed in isolated projects; significant areas are without a drainage network (e.g., Sindh). The basin lacks drainage outlets (except Left Bank Outfall Drain in Sindh).
- Emphasis was placed on structural means of reducing drainage requirements without improving irrigation system performance to reduce drainable surplus.
- Irrigation with water of marginal quality has contributed to salinization and sodification of soils.
- Salt inflows into the basin and salt loads damages resource basis (soil), natural water bodies, and water-related ecosystems.
- Low-quality water is recycled within the basin and used for irrigation.
- Groundwater depletes in terms of quantity and quality.

Source: Authors' compilation.

3. Development of Federal and Provincial Drainage Institutions

The organizational landscape for agricultural drainage, including the disposal of surplus rainfall, that has been developed in Pakistan underwent many changes until today, in this way responding to timely felt needs (table 5). A decisive point for (irrigation and) drainage was the establishment of the Water and Power Development Authority (WAPDA) in 1958–59, which caused a separation of irrigation and drainage functions between the central government and the provinces.

With the Indus Basin project (1960s), planning, design, and construction responsibility for all major development projects in the irrigation, drainage, and power sectors was shifted from the provincial irrigation departments to WAPDA, a federal, semiautonomous or parastatal body. For the time being, WAPDA operates and maintains the interprovincial drains on a cost-sharing basis with the provincial governments. The provincial irrigation departments are responsible for managing the remaining infrastructure to be financed out of the provinces' nondevelopment budgets (table 6). According to many reports, the shift of major power and functions to the federal level was poorly coordinated between WAPDA and the provinces and demoralizing to PID engineers. Most civil engineers and other professionals were attracted to careers with WAPDA, which led to a decline in the quality and professionalism of the provincial irrigation departments (Bandaragoda 1993).

Drainage schemes are planned by WAPDA, submitted to the Ministry of Water and Power, which sends proposals to the Ministry of Planning and Development for final approval from the executive committee of the National Economic Council. After the council's approval, WAPDA, the major implementing agency, acts on behalf of the Ministry of Water and Power. The provinces implement only schemes of less than 2,000 ha. Investment are funded through foreign loans, grants, and allocations of federal and provincial resources through annual development plans. Although the provinces collaborate with WAPDA during the planning process, they claim that coordination would be ineffective between the federal and provincial level, and among the provinces (Ul-Haq 1998: 97). However, for the Mardan project, the provincial irrigation department was kept on the sidelines during implementation (Freedman 2001: 23–39). The department inherited a project for which it had neither the personnel nor the organization nor the finances. On WAPDA's side, its early reliance on foreign consulting firms slowed down the development of in-house expertise.

In the 1950s, the government's response to the alarming proliferation of areas with high water tables was a large-scale program of land reclamation, known as Salinity Control and Reclamation projects (SCARP). These projects were followed up by constructing main open drainage infrastructure to take care of surface run-off. The implementation of SCARPs was accompanied by substantial research for which the SCARP Monitoring Organization was created. The International Waterlogging and Salinity Research Institute (IWASRI), the MONA Experimental Research Station, the SCARP Monitoring Organization, the Reclamation Research Institute–Lower Indus Management, and so on are WAPDA's subsidiary organizations or units established for specific research, monitoring, and evaluation functions.

With the formation of WAPDA, the Groundwater Development Organization of Punjab was transferred to WAPDA's Water and Soil Investment Division. The first legislation on groundwater was enacted when vertical drainage projects had started: the Punjab Soil Reclamation Act of 1952 (table 5). The act created the basis for the Soil Reclamation Board, later suspended (1964–65); its executive powers for O&M of the public SCARPs were transferred to SE SCARP, established within the provincial irrigation department. However, the SE SCARPs did not become responsible for groundwater development.

WAPDA's establishment act stipulated that it would be in charge of the development of groundwater resources and would issue official area-specific rules—which have never been formulated.

Table 5 Evolution of organizational set-up for drainage

Year	*Event*	*Purpose/result*
1917/18	Drainage Board created for Upper Chenab Canal	Investigations for controlling canal seepage.
1920	Drainage Division created in Upper Bari Doab Canal with a drainage engineer	
1925	Waterlogging Inquiry Committee (WIC) created with a superintending engineer	Advisor to government. Waterlogging investigations (1927).
1928	WIC replaced by Waterlogging Board	
1930/31	Irrigation Research Institute establishedin provincial irrigation department	Research on seepage drains in Upper and Lower Chenab Canal.
1932	Drainage circle created with superintending engineer Reorganization of drainage circle, i.e. two divisions (jurisdiction over Chaj and Rachna)	Organized around natural drainage basins to better tackle construction of seepage and seepage-cum-storm drains. Investigations in deep water table areas (1937).
1939	United with Upper Jhelum Canal Circle and Lower Chenab Canal Circle	
1940	Land Reclamation Board created	Recommended nonstructural measures Salinity and alkalinity survey in Punjab (1943)
1944	Northern Drainage Circle createdwith jurisdiction over Chaj and Rachna	Independent circles better suited to construct and maintain drains.
1945	Directorate of Land Reclamation created	To reclaim saline and sodic soils.
1947	Drainage circles closed; Drainage divisions attached to irrigation circles	Drainage divisions better suited because already in charge with maintenance of canals.
1951	Two drainage circles created, separate from irrigation circles	
1952	Soil Reclamation Board created for groundwater management	Established after FAO investigations.
1954	Groundwater Development Organization created	Later transformed into WAPDA with a Water and Soil Investigation Division.
	Drainage circles abolished	To economize expenditures.
1958	Drainage circles reestablished Director of drainage appointed in the office of the chief engineer, irrigation (West Pakistan)	To improve land reclamation and drainage.
1959	WAPDA established	For investigation, planning and implementation of control means. Master Plan, Regional Plan (1967). Action Program for Irrigation and Drainage (1965–75). Accelerated Program "Waterlogging and Salinity Control" (1974/75 to 1984/85), revised in 1985 for a 21-year period.
1964/65	Soil Reclamation Board suspended	Responsibilities/power transferred to PID, SE SCARPs except groundwater management.
1977	Federal Flood Commission	Approval of flood control schemes; forecasting; evaluation/monitoring of National Flood Protection Plan.
	Drainage Circles in Lahore, Faisalabad, Sargodha; Drainage Divisions in other zones	Functional units (O&M of drains).
1995	WAPDA takes over O&M responsibility for interprovincial drains	Cost-sharing between federal state and provinces.

WAPDA Water and Power Development Authority; O&M operation and maintenance; FAO Food and Agriculture Organization; PID provincial irrigation department; SCARP Salinity Control and Reclamation project; SE SCARP superintending engineer SCARP.
Source: Authors' compilation.

Table 6 Multilevel, multiorganizational arrangement for drainage (prior to institutional reforms)

Activity	***Federal level***	***Provincial and local level***
Policymaking	Ministry of Water and Power	Planning and Development Board (Punjab) / Dept. (Sindh) of provincial government.
Research	IWASRI, MONA, SCARP SMO, Reclamation Research Institute	
Planning and design	WAPDA	PID
Investments Irrigation and drainage systems Groundwater systems	Ministry of Water and Power, Planning, and Development Division of Ministry of Finance, WAPDA, Cost sharing with farmers[a]	Planning and Development Board (Punjab) / Dept. (Sindh) of provincial government, Finance Dept. Cost-sharing with farmers[a]
Implementation and construction	WAPDA, private firms	PID
Coordination and supervision	WAPDA	Planning and Development Board (Punjab) / Dept. (Sindh) through Steering Committee PID
Operation and maintenance Link canals Branch, minor, distributary Watercourses, farm outlets SCARP tubewells Private and community tubewells Interprovincial drains Main drains Tertiary surface drains Tile-cum-sump schemes	WAPDA WAPDA	PID-SE Irrigation Circles Farmers PID-SE/PD SCARP Individuals + farmers' group PID-SE Drainage Circles DBGs, PID DBGs, PID
Financing O&M (irrigation) Financing O&M (drainage)		Finance Dept., farmers Finance Dept., farmers (Sindh)
Irrigation water quality Groundwater (SCARP areas) Drainage effluent Irrigation water	SCARP Monitoring Organization (WAPDA)	 PID
Land reclamation		Directorate of Land Reclamation + PID, SE Irrigation Circles
Farm operations (irrigation and drainage)		Owner operators, tenants

IWASRI International Waterlogging and Salinity Research Institute; MONA Research and Experimental Station; WAPDA Water and Power Development Authority; PID provincial engineering department; SCARP Salinity Control and Reclamation project; SMO SCARP Monitoring Organization; SE superintending engineer.

a. For lining watercourses and construction of tertiary open drains.

Source: Authors' compilation.

More confusion was added by the Local Government Ordinance of 1979, which proposed that all groundwater falling within the local area of a union council comes under the control of that local government body. All acts are still in place, which leaves three authorities in charge of groundwater development, the federal WAPDA, the provincial irrigation departments, and the local governments. In fact, however, everybody has free access to extract groundwater without any limitations. Neither rights to groundwater nor obligations for its use have been specified.

WAPDA operates and maintains infrastructure for a test period of 1 to 2 years after construction and then passes it over to provincial irrigation departments (Freedman 2001). The facilities then are under provincial responsibility once a special duty officer has issued a “no objection” certificate. The secretary of the Irrigation and Power Department, heads the PID in the provinces under the Ministry of Irrigation and Power. Under the irrigation secretary, chief engineers head zones where they carry out departmental functions, some with territorial jurisdiction, others with functional duties. Each zone has a number of canal circles and subject-specific circles, for example, SE Drainage Circles, SE SCARP. For management purposes, a *circle* is a complete unit responsible for operation and maintenance of a defined drainage system under a superintending engineer. For O&M, a circle is further subdivided into divisions with executive engineers that are under the administrative control of SEs. On financial and accounting matters, an executive engineer is independently responsible to the audit department. Below subdivisions, headed by subdivisional officers, come sections with subengineers who are assisted by a fleet of workers and other laborers for maintenance works.

Reclamation of saline land is under the responsibility of a provincial irrigation department’s Directorate of Land Reclamation and its irrigation circles. The prime objective of the Directorate of Land Reclamation is to monitor salinity trends in canal command areas and devise remedies, for example, leaching saline and sodic soil and applying associated techniques. In 1945, such a directorate was established as a unit within the Punjab Irrigation and Power Department after salinity was recognized as a major problem (its predecessor was the Drainage and Land Reclamation Board from 1917). In Sindh, a similar unit existed, but the directorate is no longer functional.

Nobody has monitored irrigation water quality within the system except for water in reservoirs, groundwater quality, and the quality of water needed for soil reclamation activities. To define fresh and saline groundwater areas, the SCARP Monitoring Organization of WAPDA employs its own standards, which are different from those applied by the Directorate of Land Reclamation for its activities. Both organizations use electrical conductivity (EC), residual sodium carbonate (RSC) content, and sodium absorption ratio (SAR) as classification criteria. While the SCARP Monitoring Organization defines the usable class at EC 1.5 dS/m, RSC to 2.5 meq/l, and SAR to 10, the directorate determines “usable” waters at an EC <1.0 dS/m with the same SAR at 10. Only recently have uniform standards been proposed (appendix table C2), and the Pakistan Council for Research in Water Resources has started a National Water Quality Monitoring Program. However, there are no operational rules for irrigation water quality, and no decision has been made about which organizational unit will monitor and implement them.

In the four provinces, provincial irrigation departments have acquired about 100,000 employees (Punjab with more than 50,000; Sindh around 32,000). Despite the large work force for O&M, managers were unable to manage drainage infrastructure in accordance with requirements due to underfunding and a lack of professional personnel. However, underfunding is not the only reason for poor service. The organizational structure and the distribution of responsibilities remained exactly as left by the colonial administration except that new disciplinary wings—SE Drainage and SE SCARP—were added (Bandaragoda and Firdousi 1992; Shahid 1994). Management studies on the provincial irrigation departments’ establishment and performance point to major organizational problems (Ul-Hassan 1999: 22; Ul-Haq 1998: 99–102), including:

- Too much centralization. Over the years, regulations and practices have moved decisionmaking upward.
- Uneven distribution of work load. Organizational units are either over- or underworked.
- Working places not equally attractive for semployees. Their attractiveness decreases in the following order: irrigation circles, SE SCARPs in fresh groundwater areas, drainage circles, SE SCARPs in saline groundwater areas.
- Diffusion of responsibility. Staff responsibilities are often spread over a number of functions with insufficient training and inadequate discipline.
- Dispersion of authority. Some elements of organization spend too much time and effort at the expense of others, without adequate support of assigned authority.
- Erratic controls.
- Poor communication methods and lack of interagency and farmer communication.

An issue of concern is the overlapping jurisdiction of canal, tubewell, and drainage wings within the same geographical area. The sharp fragmentation between irrigation and drainage units has meant that nonstructural means of reducing drainage requirements have been rarely applied. Intra-agency coordination could be solved by bringing all these functions as close as possible to each other under the same administrative supervisor, namely the superintending engineers, but no such attempt has been made.

An important institutional change came about in the 1970s, when extensive research in canal commands was undertaken by the MONA Reclamation Experimental Station. Together with WAPDA's Revised Action Program (1976–77), the station found substantial water losses in watercourses (35 percent to 40 percent). The first watercourse improvement program, the On-Farm Water Management (OFWM) Pilot project, started in 1976–77, comprised lining of watercourses and remodeling of outlets. To implement OFWM-projects, on-farm water management directorates of the provincial agriculture departments (PADs) were established. This meant that the traditionally extension-oriented PADs shifted emphasis, first, to construction, and later to social mobilization of farmers to establish the water users associations required by donors for OFWM projects. When irrigation departments refused to take over watercourse lining and social mobilization of farmers, their primacy in irrigation matters was challenged, just as WAPDA already had succeeded in doing at the national level (van der Velde and Tirmizi 1999: 3).

Starting with OFWM projects in the 1970s, water users associations were established for watercourse lining; drainage beneficiary groups for constructing tertiary open off-farm drains, watercourse escapes and for tile drainage schemes; community tubewell groups that have either taken over public tubewells, or replaced them with tubewells. Water users associations did not survive after watercourse lining, and it remains to be seen whether drainage beneficiary groups and community tubewell groups will.

Drainage enjoyed high subsidies, since drainage investment and management costs were never backed by drainage charges or drainage cess, the exception being vertical drainage in fresh groundwater areas by means of tubewells. This burden on national and provincial treasuries was one of the driving forces behind reforms that started in the early 1990s; poor performance and economic losses due to resource depletion were others.

The radical institutional reform process came about on the initiative of the World Bank. The World Bank document *Pakistan: Irrigation and Drainage: Issues and Options* (1994) pointed to poor irrigation performance, which, together with the lack of an efficient drainage system, would have caused widespread waterlogging and salinity on irrigated land, inefficient water delivery and use, inequitable water distribution, and overexploitation of good-quality groundwater. The World Bank demanded the abandonment of government irrigation policies (World Bank 1994). It advocated a phased implementation of pilot projects in canal commands in which public utilities would be set up; a strengthening of federal water agencies and provincial water authorities; and a phase-out of subsidies for operation and maintenance within 7 to 10 years. In 1997, the government of Pakistan and the multilateral lenders finally agreed that the first phase of the 25-year National Drainage Program would further institutional change and provide for a remodeling of irrigation and drainage infrastructure and construction of new drains (Wambia 2000: 366). The ambitious reform package covers the whole irrigation and drainage sector with its many bureaucratic establishments at the federal and provincial level. It requires a fundamental change in the relationbetween federal agencies and provinces in terms of power and finances (see section 6).

Box 3 Pakistan's institutional profile (prior to reforms)

- Planning, design and construction by federal government authority (WAPDA); investment financing out of national and international resources. Coordination with provinces ineffective
- Drainage management by provincial irrigation departments financed out of provincial nondevelopment budgets
- Management responsibility fragmented within provincial irrigation departments: between irrigation and drainage circles, drainage circles and SE SCARPs, drainage circles and CE flood control, irrigation circles and Directorate of Land Reclamation. Coordination, if any, poor
- Drainage circles subordinate to CE Irrigation Circles, which affects their budgets
- Drainage beneficiary groups for implementing tertiary surface drains and for managing tile drainage schemes initiated by on-farm water management/provincial agricultural departments and outside provincial irrigation department jurisdiction
- Beneficiaries do not pay capital charges, and are not charged for O&M cost of drainage service provision in Punjab; a drainage cess is levied in Sindh.
- No standards and operational guidelines for irrigation water quality; no regular monitoring.
- Responsibility for groundwater development and regulation is confusing, with open access prevailing.

Source: Authors' compilation.

4. Drainage Management

As provided in the Constitution of Pakistan (1973), management of drainage infrastructure is the provinces' affair. Additional organizational units within the provincial irrigation departments were established as responses to technical interventions: superintending engineer (SE) drainage circles are assigned responsibility for open drainage infrastructure; SE SCARPs operate and maintain tubewells (vertical drainage); depending on location, tile drainage schemes are either under SE drainage circles or SE SCARPs.

The following sections draw attention to management performance and the reasons for the generally observed poor provision of drainage services.

State of Surface Drainage Infrastructure

Ul-Haq (1998: 86) mentions that the designed capacity of surface drains is already inadequate and lower than normally required for effective drainage, particularly during intense rainfall events. Meanwhile, the expansion of irrigation areas and rising cropping intensities required higher capacity, but due to poor maintenance of major parts of the drainage network after construction in the 1960s, the situation instead became worse. Weed- and sediment-clogged drains caused sloughing and erosion of slopes. A single season's weed growth is high enough to cause backstopping of water during the monsoon season and inundation of adjacent fields. Main drains deteriorated to the point where rehabilitation to open up the pipes and restore the earthwork is almost as much work as constructing new drains. For lack of maintenance over the past decades, infrastructure is desparately in need of rehabilitation and remodeling.[4] During peak flow seasons in drains, when rivers are also in a high flood stage, poor outflow conditions for main and branch drains critically impedes effective drainage. Decreased capacity and rising flow depth causes flooding of adjacent areas. Untreated municipal and industrial effluents discharge into the drains further reducing their already insufficient capacity, increasing maintenance requirements, and creating health risks for urban and rural residents, and field staff.

Maintenance Responsibility

Maintenance of major open drains is under the responsibility of the PID's se drainage circles, their divisions, subdivisions and sections. Drainage circles are, after a tumultuous history (table 5), under the administrative command of chief engineers (CE). In Punjab the circles are under the chief engineers of Lahore, Faisalabad,and Sarghoda; Sindh has one SE Drainage Circle (Kotri) and three project directors (PD) under the chief engineer for development, i.e. Sukkur, Khairpur and Naushero Feroze.

Drainage circles have executive units, the divisions and subdivisions, which are headed by executive engineers (XENs) and Subdivision officers (SDOs), respectively. On financial and accounting matters, a XEN has discretionary power but is responsible to the Audit Department. He approves maintenance expenditures up to a certain limit but needs approval of finances if plans exceed a certain amount. Sections are headed by subengineers with *mistries* (technicians), *mates* (supervisors and organizers), *beldars* (unskilled workers). Beldars do small-scale weeding works and minor repairs of roads and other infrastructure. In a few areas not covered by drainage circles, irrigation divisions or subdivisions are in charge of maintaining drainage infrastructure. In Sindh, the Left Bank Outfall Drain works are now under the jurisdiction of the Sindh Irrigation and Drainage Authority (SIDA) and the Nara Canal area water board.

4 The updated NDP Three Year Investment Plan 1998-2000 provided Rs. 16,491.63 million for drainage and maintenance including de-siltation of surface drains, rehabilitation, remodeling, extension and other works (see PIDA 1999a).

Drainage circles are responsible for catchments bordered by rivers or channels (link canals, branches, distributaries, and minors). These catchments (i.e., boundaries of jurisdiction) do not coincide with canal command areas of irrigation circles and are, as a rule, greater than canal commands: the Lahore Drainage Circle's area is about one and a half times larger than the Lahore Irrigation Circle's territory.

Despite the huge contingents of mistries, mates, and beldars assigned to maintain specified stretches of drains, the relentless deterioration of the drainage infrastructure continues. Most of the drains are so heavily contaminated by effluents and their banks are so eroded, that maintenance work is too risky for the beldars to execute manually. Special machinery and additional funds are required, but scarce funds limit the availability of mechanical spare parts and replacement of equipment, which has to be financed out of the provincial nondevelopment budgets.

Budget constraints also limit contracting out. For the Left Bank Outfall Drain in Sindh, private firms under performance contracts provide maintenance services, financed by the Asian Development Bank. Yet it is not known how the Sindh Irrigation and Drainage Authority will proceed after this three-year, external funding terminates.[5]

Superintending engineers with the Punjab Drainage Circles claim a lack of skilled staff among its huge contingent of mistries, mates and beldars. In Sindh, an even larger work force is available, but poor motivation and professionalism as well as inappropriate budgets are constraints for providing adequate drainage services. According to the 1992 yardstick, one beldar tends one mile of a high-capacity drain and two miles of a low-capacity drain. Recruitment was halted five to six years ago, new personnel were not hired, and the staff was reduced due to retirements. However, compared with internationally accepted indicators, which set for O&M of irrigation and drainage systems 0.5 personnel per kilometer for low-mechanized and low-waged countries, the Drainage Circles establishment reaches international standards (Bos and Nugteren 1974, table 5) in Lahore with 0.5 personnel per kilometer, and is above with 1.2 in Faisalabad and 1.5 in Sarghoda.

Financing Maintenance

Underfunding is not the sole cause of poor maintenance, but sufficient funds are still crucial. The administrative procedure for assessing budget demands and allocating budgets to drainage circles shows that providing reliable and adequate maintenance is impossible to attain. PIDs receive their budget from the provincial treasuries, approved by the finance departments, that are allocated to chief engineers, who distribute budget among categories, for example, SE/PD SCARP, SE irrigation circles and SE/PD drainage circles, and components, for example, establishment, spare parts, fuel. Unlike irrigation services, the costs of providing drainage services are not charged to irrigators in Punjab, but in Sindh a drainage cess is levied on tubewells in saline and fresh groundwater areas.[6]

FRAMING O&M BUDGETS OF THE DRAINAGE CIRCLES. Annual field surveys form the basis for the XENs Demand Statements that they submit to the Superintending Engineer of the respective Drainage Circle. At the CE level, the SEs' demand statements are put together with those of SE Irrigation Circles, SE/PD SCARP and others, and submitted to the Secretary Irrigation, PID, and finally to the provincial governments' finance departments.

For maintenance programs, bed level–width losses of main drains are inspected every 328 m. If losses reach 40 percent of designed discharge capacity, maintenance activities become part of the annual programs. They are translated into budgetary demands by using a yardstick that defines a certain amount that can be allocated per kilometer of drains. The reference point is bed-level width: For drains wider than 4.6 m, Rs. 7,000 per km are allocated;. for a bed-level width of 3.28 m, Rs. 2,500 per km. On average,

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5 This option is yet not assessed in terms of its economic performance and the quality of services provided.

6 For irrigation cost recovery, see Ul-Haq 1998: 90–93.

maintaining 1 km of drain is set between Rs. 12,500 and 18,750 in Punjab. In Sindh, the rate is Rs. 8,063 per km, but for small drains and disposal channels, it is Rs. 3,500 per km.

The Finance Department has not updated the yardstick for framing maintenance budgets since 1992, but 6 percent can be added annually to adjust for inflation. The revision of the yardstick in 1963 provided that routine maintenance could be tackled but did not allocate adequate funds to deal with the backlog of negative effects. Nor did it take into account the additional needs triggered by overuse of the system due to agricultural development and increased trespassing. In 1982 and in 1992, the revisions again did not provide for deferred maintenance needs and only partly covered the growing rate of physical deterioration. The yardstick does not make provision for purchase and maintenance of durable goods such as vehicles and other equipment,[7] and therefore does not allow the costs of technological changes to be captured. Apart from this, the prices of labor and materials have increased, and inflation has exceeded the 6 percent adjustment permitted. It is reasonable to assume that the finance departments have used unadjusted yardsticks as a means of keeping expenditure below actual needs to avoid increasing the burden on the provincial treasuries.

Maintenance Budget Allocations, Demand Statements, and Actual Needs. Regular routine maintenance expenditures are allocated out from the nondevelopment budget to PIDs through the finance departments. Overall budget allocations to PIDs are an estimated 50 percent of overall O&M requirements—not only for drainage. At the CE level, the CE decides on distributions among categories and the, less flexible, components. Due to overall fixed establishment costs such as salaries, benefits, and operational cost, 49 percent of O&M budget is not subject to redistribution, and only minor cuts can be made. Second priority is O&M of SCARP tubewells, which absorb 35 percent, of which 85 percent is paid to WAPDA for electricity tariffs. For O&M of canals, 11 percent is spent; for O&M of flood and drainage infrastructure, only 4 percent was left in 1997, and the remaining 1 percent went for other items. In addition, delays in releasing the budget reportedly make effective planning and predictable utilization impossible. Senior managers further reduce allocations to SEs by retaining “reserve funds” whose distribution would lack rational basis (Ul-Haq 1998, p. 90).

These overall figures are substantiated by sample information of from a Drainage Circle in Punjab. In the fiscal year 1998–99, the yardstick-based demand of the Lahore Drainage Circle was Rs. 20 million, against allocated Rs. 10 million, and realistic O&M funds approaching Rs. 30 million, which means that the allocation was only a third of the funds needed. Allocations to drainage circles, all in all, are between one third and one half of the demand calculated by an already outdated yardstick. The estimated expenditure of a Drainage Circle is Rs. 22.2 per ha, of which Rs. 3.7 per ha is spent on maintenance work and Rs. 18.5 per ha on establishment. As a consequence, drainage circles manage scarce funds and set priorities according to identified “acute needs” (or crises), and not according preventive maintenance requirements. However, little discretion is left for interventions unless the budgetary position of drainage circles improves.

Only recently, the Finance Department have been earmarking budget shares for each category. Now the Finance Department alone is entitled to reappropriate scarce funds to correct imbalances among categories. This does not necessarily work to the advantage of the drainage circles because allocations for drainage depend on the political appreciation of drainage and the opportunity cost perceived.

Under budgetary constraints, maintenance of irrigation canals to maintain water supply is invariably given priority over O&M of drainage infrastructure. Wambia (1998) assumes that the constituency for drainage is simply lacking or absent in irrigation-obsessed Pakistan, unless farmers are lower riparians as they are in Sindh, owning and cultivating flood prone lands. Due to notorious underfunding, financing drainage services has become an issue. At present, budget allocations for maintaining open drains are not supported by user charges in Punjab, and irrigators do not contribute toward maintenance costs. Since the 1990s,

7 However, in some projects, durable goods were purchased and transferred to PID drainage units.

industrial plants and municipalities in Punjab have been obliged to pay a drainage cess to dispose of sewage into the main drains. Industry pays Rs. 11,000 per cusec per year irrespective of the effluents' composition.[8] This drainage cess is collected by staff of the Revenue Department and becomes part of the provincial treasury. Industry's contribution toward funding is, however, marginal (the collection rate is unknown), and municipalities do not pay.

Management of Tile Drainage Schemes

After a two-year test period while WAPDA operates and maintains the tile drainage units, tile schemes are transferred to the provincial irrigation departments. Operation is not continuously necessary if drainage effluent discharges gravitationally into the main drains. If effluents discharge into a sump, tubewells lift the water and dispose of it in either watercourses or drains. Drainage effluents can be used to reclaim saline land and to expand the irrigated area. Checking water quality and soil moisture is necessary, and cycling ratios should be defined and recommended to farmers. Regular monitoring and maintenance of electricity-driven pumps and associated networks is required to avoid operation problems that occur due to power fluctuations and other interference.

However, SE drainage circles or SE SCARPs rarely operated and maintained the schemes. In the Drainage IV project area, for instance, out of the 79 sump units (Phase I) only 30 percent work—the rest needs to be rehabilitated. Therefore, it is hoped that farmers take over O&M responsibility and costs. While farmer participation was successful in the FESS area, where community group members bear O&M costs, farmers hesitated to take over O&M of the tile drainage schemes in LBOD, since no official social mobilization effort was made. However, farmers interviewed thought they might have participated had they been involved in planning and implementation.

Management of SCARP Tubewells

After construction and a two-years care phase, deep SCARP tubewells are transferred to SE/PD SCARPs for O&M. In the beginning of the SCARPs, there were marked improvements in surface soil salinity, profile salinity-sodicity, water table depth, and supplementation of irrigation water supply, but operation declined while costs increased.

At first, SCARP tubewells in fresh groundwater areas provided about 43 percent of the irrigation water supply. This amount dropped because the electricity-driven pumps frequently broke down. Though designed with an operation factor of 57 percent, the tubewells actually operated at only 38 percent. However, canal water and the irrigation water provided by public tubewells was close to meeting irrigation requirements. But small farmers in particular, who had no access to private tubewell water, complained about water shortages and lack of synchronization of operation with crop-water requirements. Many farmers claimed that the local tubewell operators (PID staff) were the source of their troubles, that, lacking supervision, the operators ran the tubewells to suit themselves, and favored large farms over small farmers.

SCARPs in saline groundwater areas, which are designed to meet drainage requirements, did not sustain adequate water table depth. In general, the yearly pumping was less than required to balance annual recharge to groundwater, due mainly to seepage from canals.

Budget requests for O&M of SCARPs are calculated by a yardstick that has not been revised since 1983. Fund allocations were not, however, based on this yardstick according to the PID requests. Although O&M of SCARPs consumed the highest share of PIDs' budgets, allocations still did not meet demand.

8 Companies apply at XEN to use the drains, and after the Environment Department issues a "No objection certificate," they sign an agreement with PID. It is said that quantities are controlled at source.

SCARP tubewells consumed an estimated 35 percent of the annual O&M budgets, of which 85 percent was spent for electricity tariffs. The tubewells maintenance costs were between 60 percent and 65 percent of the overall maintenance allocations. The Punjab government is currently charging double water charges in SCARP fresh groundwater areas, which can be interpreted as a drainage cess (farmers pay charges for tubewell water even when they did not get water, and even after official closure). In Sindh, O&M of tubewells are charged through a drainage cess. Net recovery by water charges was negligible because water charges were far below cost. Until 1973, the water charges collected covered O&M expenses, but from 1974/75 on, working expenses—mainly because of SCARPs—outpaced the revenue, leading to an ever-widening deficit. Since increasing water charges to balance expenditures was politically unfeasible, high costs meant that public tubewells were closed and transferred to, or replaced by, community tubewells.

Conclusions

Provincial irrigation departments have been struggling with open drainage networks designed for capacities lower than required for effective drainage, particularly during intense rainfall events, and lacking proper outfall conditions. Drainage infrastructure is, in general, in a poor state. Management of most tile drainage schemes has been nonexistent. The poor performance of public tubewells—and the high subsidies provided—stimulated their transfer to the private sector and to farmers groups. Maintenance of the open drainage network has been deferred over the past decades due to budgetary constraints and nonbudgetary reasons.

About 50 percent of a PID's already inadequate O&M budget is not subject to redistributions (salaries, benefits). SCARP tubewells receive high priority, consuming about 35 percent, and canals the next highest at 11 percent. This has left only 4 percent for flood and surface drainage in the 1990s. In terms of funding, SE drainage circles ranked lowest in the organizational hierarchy, and they could neither implement routine maintenance activities nor tackle the accumulated negative effects. Since budget allocations for drainage infrastructure are not backed with revenue from drainage charges, the provision of drainage services, though inadequate, are a tremendous burden on the provincial treasuries, in particular the high electricity costs of tubewell operation. Contribution toward financing maintenance services from industry is marginal, and municipalities are legally not obliged to pay.

The Punjab Drainage Circles' establishment, for example, reaches or exceeds international standards in terms of the number of maintenance personnel employed. However, the large working forces of both units—SE SCARPs and SE Drainage Circles—have been unable to cope with drainage requirements because of low labor productivity, lack of qualified staff, and PID staff indifference to the users' drainage demands.

5. Land Reclamation

An estimated 6.1 million ha of land is in need of reclamation. Soil is deteriorating faster than land is being reclaimed, and reclamation of saline land is decreasing (Javaid and others 1997/98: 44). Much of the cultivated land area in Punjab contains too much salt.

As the Indus irrigation system is a continuous flow system, farmers receive their share of water regardless of needs, which leads to periodic over and underirrigation. It makes leaching of salts to lower soil layers difficult, because they cannot increase the amount of water needed for leaching. Thus, to undertake reclamation activities, farmers must apply for additional water for leaching purposes.[9]

Reclamation of saline land is a concerted action of the PID's irrigation canal circles, the Directorate of Land Reclamation (DLR), and individual farmers.[10] The directorate has the primary objective of monitoring salinity trends in canal command areas and programming remedial activities, for example, leaching saline and sodic soil and applying associated techniques. When the directorate was established (1945) as a unit within the Punjab Irrigation and Power Department, most irrigated land was expected to go out of production within the next 70 to 80 years due to waterlogging and salinization and decreasing water allowances to fields (Javaid and others 1997/98: 35).

Responsibilities for Land Reclamation

For planning and implementation of reclamation activities, the Directorate of Land Reclamation is under the administrative control of the Irrigation Canal Circles. This means that DLR staff develop and propose Tentative Reclamation Programs that are approved and implemented by irrigation staff. Whether cultivators become eligible for reclamation depends on the outcome of consultations between executive engineers (XEN), superintending engineers (SE), and the Directorate of Land Reclamation. XEN and SE have final decisionmaking authority over Tentative Reclamation Programs. Selection of sites and extent of area needs approval from the SE concerned. DLR staff then conduct a second survey (canal assessors do the first) to check salinity in the reach of channels where a reclamation supply has been agreed upon. Landowners are asked to sign agreements that are submitted to subdivisional offices (SDO). The finalized reclamation schemes are forwarded to irrigation staff involved, for whom XENs prepare Shoot Statements detailing who is eligible. After approval by SEs, DLR staff frame and sanction reclamation turns, and SDOs, in receipt of installation orders from SEs, give instructions to overseers for the installation of pipes.

Water Shortage Impedes Reclamation Activities

Decisions on the scale of reclamation operations depend, above all, on whether irrigation staff can mobilize additional water beyond the regular irrigation supply. These decisions are not related to the cultivators' demand or technical requirements as perceived by DLR staff. Irrigation staff (executive engineers and superintending engineers) are already constrained in supplying sufficient irrigation water into distributaries, because cropping intensities are higher than 100 percent. Water availability in distributaries is frequently insufficient because of, for example, limited design capacity, reduced discharge due to inadequate maintenance, and the like. Although design capacities of irrigation channels and outlets have a 10 percent potential for reclamation operations, demand for irrigation water has increased, eating

9 The water allocation method is *warabandi*, which means a continuous rotation of water in which one complete cycle of rotation lasts 7 days, and each farmer along a watercourse receives water during one turn in this cycle for a fixed length of time. The duration is proportional to the size of the landholding to be irrigated.

10 This section applies only to Punjab, and relies heavily on Bandaragoda and ur Rehman 1994.

up the 10 percent potential. Due to a general shortage of water, irrigation circles did not approve reclamation turns.

Administrative Irregularities and Noncompliance by Farmers

Field investigations revealed several distortions that cannot be attributed to water shortage. Influential farmers were more successful in gaining access to reclamation water. Most applications were processed by intervention of influential farmers and approved on the basis of political considerations; only one fifth of the applications undergo the normal procedure (Bandaragoda and ur Rehman 1994: 19–25). Head and middle reaches of distributaries received only a fraction of the reclamation allowances, and the tail reaches even less. In addition, no reclamation outlets were installed in the tail reaches of distributaries. Although XENs certified that there would be no shortage in the tail reaches, water shortages did occurr, because irrigation staff fed no extra water into distributaries. Ineligible farmers used reclamation turns, although their fields were not part of the reclamation schemes. Eligible farmers misused reclamation water for regular crop production and for extending their irrigated areas. There is evidence that rules are being broken due to weak monitoring and nonenforcement of sanctions on rule breakers—be they farmers or irrigation staff.

Farmer Participation in Land Reclamation Activities

In 1998, the Directorate of Land Reclamation introduced a new procedure for undertaking reclamation operations in close collaboration with farmers. It foresees the establishment of reclamation *(Islah-e-Arazi)* committees to make planning and implementation more transparent and objective-related. These committees are, so far, informal and lack legal recognition. Reclamation committees comprise farmers whose land is selected by DLR for reclamation and who, therefore, are eligible for additional water allowances for leaching purposes. Due to technical reasons, a committee comprises farmers served by a common watercourse.

DLR officials assume that reclamation committees provide advantages over the previous procedures. Their establishment would correct the poor level of information related to reclamation programs reaching the farmers as a common group, which is regarded as a major reason for misuse of reclamation water. The committee members would know who else is eligible to receive reclamation water shoots. Other group members could also detect ineligible users and illegal users[11] more easily than officials. If water is used illegally or by ineligible persons, group members would report them to land reclamation officials who can impose penalties. According to the Canal and Drainage Act (1873), violation of rules is subject to fines (six times the water charges), but they are rarely enforced. In addition, assigned users would monitor whether schedules are modified by irrigation circle staff, whether they receive their additional shoots, and whether additional outlets are in place, investigate the causes, and report to DLR staff. DLR staff can bring it to the notice of concerned XEN who can take action.

Conclusions

Both inadequate drainage infrastructure and poor irrigation system performance have increased the need for land reclamation. The current rate of land reclamation is lower than the rate of soil deterioration.

A major institutional weakness is that a separate unit—the Directorate of Land Reclamation—is assigned responsibility for land reclamation within the Punjab Provincial Irrigation Department. The directorate is subordinate to the irrigation circles but intra-agency coordination has been poor, and both units have been struggling over water. This separation of responsibility has caused externalization of the impact of actions

[11] Farmers who use reclamation shoots for irrigation and not for leaching or for supplementing their regular turn, extending their area under irrigation, or both.

undertaken by one unit (irrigation management), and assignment of responsibility to another departmental unit for implementing corrective means. In the process of reorganizing the irrigation and drainage sector, responsibility for land reclamation must be rethought. It may be advisable to assign this responsibility to the irrigation system management units.

For the time being, leaching of salts is difficult because farmers cannot obtain the additional water needed for leaching. All farmers receive their share of water regardless of needs. Whether water allocation rules and operational procedures can be changed in the process of institutional reforms to stop soil deterioration, requires careful investigation.

6. Participation in Drainage Investment and Management

The common feature of poor operation and maintenance in state-managed irrigation systems has led to a worldwide trend of transferring irrigation management to user organizations. Although performance is worse in drainage systems, only a few countries have attempted participation in drainage—Pakistan is one of them.

Since drainage is different by nature from irrigation, provision, operation and maintenance of drainage makes cooperative solutions troublesome—but not impossible. Like irrigation, drainage technology creates interdependencies among users that demand collective action and, consequently, governance and management regimes that guarantee rule enforcement. Unlike irrigation systems, drainage infrastructure has the following salient characteristics.

- It is jointly used by many farm units, and congestion may occur if the technical capacity reaches its limit.
- In drainage, it is more difficult than in surface irrigation, if not impossible, to exclude others from consumption. Failure of the exclusion principle to apply provides incentives for uncooperative, individualistic behavior and free riding.
- Drainage may provide local public goods that serve a farming community, rural settlements, and industry.
- If drains empty into freshwater bodies or elsewhere, they cause off-site externalities. One group of users may benefit from disposal, while others or the society as a whole bear the costs.

Due to these characteristics, it is commonly believed that government intervention is necessary. Experiments in Pakistan are noteworthy, since they challenge this assumption.

In Punjab province, participatory approaches to drainage investment and management at the local (micro) level apply to all drainage technologies—open, tile, and vertical drainage. In Sindh province, participatory approaches have been tried only in vertical schemes.

Participatory Approaches in Tertiary Open Drain and Tile Drainage Schemes

Local drainage organizations, drainage beneficiary groups (DBG), are occasional phenomena in Pakistan. There are 25 to 30 DBGs for tertiary open drains in the Second On-Farm Water Management project, Dera Ghazi Khan, Punjab, and 3 DBGs were established on tile drainage schemes in the FESS area. Since replications are planned in other canal command areas, analysis of supporting and limiting conditions for their establishment, their investment contributions, and early management experience may provide some valuable insights.

Site Specifications, Drainage Technology and Group Formation

Drainage beneficiary groups are established in areas where agricultural land has no natural drainage or access to main drains through *tertiary open drains;* more specifically, where areas need surface drainage infrastructure (Punjab Agriculture Department (Water Management) 1998) (appendix C, table C4):

- To drain ponds and low-lying waterlogged fields caused by heavy rains or floods.
- To dispose of surplus water in watercourses during monsoon rains and the slack irrigation period to prevent fields in tail reaches from being flooded for lack of watercourse escapes.

- To provide outlets for drainage effluents from tile drainage systems.

Projects in Punjab, where drainage beneficiary groups are established, are not designed to drain large areas where the water table rise is mostly due to canal seepage, because tertiary drains would not significantly lower the water table. In this respect, the Second On-Farm Water Management (OFWM) project, Dera Ghazi Khan, made major modifications in the original plan. The consultants recommended surface drainage systems only in areas where waterlogging is caused by heavy rains, or where watercourses have no escape structures at the tail end (ADB; Govt. of Punjab; Director General of Agriculture (Water Management 1994): 9-4). OFWM has two criteria for site selection: (1) that the beneficiaries must be able to manage and operate the scheme and be willing to form a group; (2) that main drains must be near-by, functional, and large enough to handle overflows during the monsoon season.

The type of drainage used quickly proved effective. In the Second On-farm Water Management project Dera Ghazi Khan, after 1.5 years land recovery from surface ponding and waterlogged conditions proved successful. The ponded area was estimated at 30 percent before the project and only 1.8 percent after project implementation, and the cropped area increased by about 30 percent.

Tile drainage schemes are usually implemented in areas with shallow aquifers, brackish groundwater, and inappropriate open drainage networks.

Near Bahawalnagar, a drainage beneficiary group was established where IWASRI and the Netherlands Research Assistance Project (NRAP) constructed a tile-cum-sump scheme. It was informally transferred to the DBG of Wazirpura village after construction (no initial costs were born by the farmers). In a short time, 134 ha of waterlogged fields were drained and could be cultivated. In the FESS, Phase-I, Irrigation and Drainage project, DBGs were established on tile-cum-sump schemes to drain waterlogged pockets that remained after completion of the main surface drains. Since the installation of tiles, much of the area has been reclaimed. The establishment of tile DBGs was facilitated by social mobilization efforts and by providing access to acceptable credits.

However, forming drainage beneficiary groups for tile schemes has proven to be difficult in other places (appendix C, table C5). In the area of the Drainage IV project (Phase-I) in Faisalabad district, agricultural land was ponded by overland flows from heavy monsoon rains; fields were waterlogged throughout the year with water tables of critical depth (up to 1.5 m or 5 feet), deeper in areas without vertical drainage. Agricultural lands ceased production, show low yields of wheat, sugarcane and rice, or converted into rough grazing areas. Many small farmers in the project area had leased their fields and water rights, and migrated in search of income opportunities elsewhere, because they could not earn a decent living on the land. Land values dropped.

The Drainage IV project (Phase-I) constructed 79 independent tile-cum-sump units to drain these waterlogged lands, and under Phase-II about 65 additional schemes are proposed. Farmers, so far, have shown no interest in taking over the 79 units although no capital costs were incurred. For the 65 new units, project consultants could mobilize only two groups, and seven more said they would contribute up-front payments for investments. Reasons for this poor response may be the high initial costs and the time required for reclamation. Following the experiments of the Drainage IV project (Phase-I) where tile drains are functional, it took more than 2.5 years to realize benefits, and farmers will have to bear additional costs (e.g., application of gypsum) for land reclamation (Pakistan National Consultants 1998b: 5).[12]

[12] For gypsum pricing, marketing, and distribution, see Govt. of Pakistan, Ministry of Water and Power 2001b.

Shared Drainage Investment

Two approaches have been taken to investments in tertiary open and tile drainage facilities. One, under the On-Farm Water Management of the Agricultural Department (OFWM) received funds from the Asian Development Bank (ADB) and OECF (Japanese Government) and required no contributions from farmers. The other was under the National Drainage Program (NDP) with WAPDA as the competent agency, and OFWM and Pakistan Drainage Consultants as the implementing organizations with farmers' financial contributions.

Tertiary Open Drainage Infrastructure. The ADB- and OECF-funded projects required farmers to donate land for the drains, while the government funded the infrastructure. In the Dera Ghazi Khan project, for example, farmers provided 9 ha for construction. These farmers said that loss of land was justified by increased cropped area and crop yields. However, only about half of the farmers (57 percent) contributed land for the drains, and the others benefited from drainage without makinig any contributions. The donor farmers thought the others should be charged for the development to compensate the farmers who donated land. Finding solutions was left to the donor farmers, but they could not prevent the free riding.

Under the NDP, DBG registration is a prerequisite for approval of funds, and all DBG members must accept the terms of a scheme agreement:

- DBG members must donate the land.
- Members are not compensated for crop losses due to construction works.
- Members contribute 10 percent of the initial costs of civil works, which are levied proportionally on hectare basis
- Payments must be made up-front by deposit to a bank account.
- Members must accept that contractors will deposit excavated material on adjacent land.
- Members must spread the excavated material to the satisfaction of those farmers whose land is adjacent to the drains, and of the project.
- Members must provide unskilled and skilled labor.
- Members must guarantee contractors free and unrestricted access to the construction site for their machinery and employees.
- Members must agree to laying of field drains and their connection to tertiary drains.

Tile-cum-sump schemes. In the Drainage IV project (Phase-I, 1984–94), where 79 units were equipped with 529 km of surface drains and 864 km of tile drains, farmers were compensated for land losses and crop damages. In Phase-II, 65 additional units will be financed under NDP. The schemes were larger under Phase-I and used sumps driven by electrical pumps. Phase II is smaller, and the sumps will be diesel-driven.[13] For tile schemes, the NDP foresees that DBGs will be established, and that

- Members will not be compensated for land losses and crop damages.
- Members will provide land for sumps and discharge boxes, manholes, and disposal channels.

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13 Electric-driven pumps have an advantage over diesel-driven pumps: Electric pumps operate automatically when the water reaches a defined level, and there is no need to pay operators, which saves Rs. 3,000 a month. Diesel-operated pumps require diesel gas that has to be transported from areas far away, with costs for transportation and time, and the engines require regular and expensive maintenance. In terms of joint operation, they require less sophisticated rules for monitoring.

- Members will pay the equivalent of 10 percent of civil works costs in advance of construction (cost ranges from Rs. 6,175 per ha to Rs. 7,410 per ha.
- Members will install pump sets and construct sump houses for which DBGs collect Rs. 50,000 (this is 5 percent for a unit of 162 ha in the FESS area , where total costs are about Rs. 1,000,000).
- Members will construct disposal channels.
- Members will guarantee free access for constructors.
- Members will restore watercourses and roads.

Farmers have more readily agreed to contribute land and to refrain from demanding compensation for crop damage than to contribute to capital costs, which has been problematic. Farmers discussed several options as equivalents such as leveling land; removing trees; restoring watercourses, field drains, and roads; constructing sump discharge box and disposal channels; providing sand; providing pump set and constructing pump houses (Pakistan Drainage Consultants 1998a: 8). Others said they would like to repay through installments after a grace period, which is not in line with the NDP. In some areas, however, farmers accepted cost-sharing arrangements and sharing in kind but have been unable to finance up-front payments. Small farmers with holdings less than 2 ha refused to provide land without compensation, because the land strip needed might be half of their farmland (Ruiter 1997: 23). They could not make the 15 percent or 10 percent up-front contributions, which were too high. Now the percentage has been reduced to 5 percent. Nor can farmers contribute skilled labor for the specialized machinery needed for construction.

However, if not all DBG members agree to the terms of up-front payments, some DBGs found solutions among themselves, for example , paying the dues of other farmers who are expected to repay in installments. It has been reported that members did not want to donate land, but that a group internally compensated for land losses either in cash or land.

Conflicts over implementation

Construction of lateral drains requires approval by the SE/XEN drainage circles of the provincial irrigation departments, because they release drainage water into main drains that are under the irrigation department responsibility. In some instances, PID officers objected to drain construction, stating that the capacity of main drains would be insufficient. Meanwhile, although construction of tertiary drains is completed and drains operate, DBGs do not have formal permission to use the main drains.

Group Formation with "Ultimate" Drainage Beneficiaries, and Alternative Options

Access to public funds has facilitated group formation, but cooperation among the farmers has not been easily forthcoming. One promising approach used by OFWM was creating DBGs with *ultimate beneficiaries*, the most negatively affected farmers. It applies differently to surface and subsurface schemes:

- In *tertiary surface drainage schemes*, the ultimate beneficiaries are cultivators whose land will be drained from surface ponds and high-standing groundwater (up to 1.5 m).
- In *tile schemes,* the ultimate beneficiaries are the cultivators whose land is covered by tile drains.

The basic idea is to stipulate cooperation among the farmers who are most affected by ponding and waterlogging. Their fields form the boundaries of DBG jurisdiction. However, since they are not identical (do not match) with a hydrological catchment, others besides the ultimate beneficiaries may take advantage of drainage infrastructure, which eventually leads to difficulties in enforcing financial contributions from nonmembers.

A procedure for identifying group members, and respective boundaries of jurisdiction, has been introduced by OFWM. It foresees public display of the farmers' names, their farm sizes, the size of affected lands, and the proposed route of the drain. After scheme specifications are explained by agency staff, reviewed by farmers, and corrected by technicians, ultimate beneficiaries are identified who form the DBG. They prepare action plans that demarcate the are, and nominate the farmers to be served by drainage systems. Farmers then submit a formal application for the scheme to agency staff which originally had to be signed by more than 50 percent of the farmers. OFWM is now demanding that 100 percent participation by farmers whose land is likely to be on the drain alignment.

A major problem of forming DBGs at tertiary open drains has been the requirement that, prior to investment and implementation, rights of way for drains must be negotiated, and land must be donated as the farmers' contributions toward project cost. Farmers who lose land for agricultural production due to drain layout, often objected, and inner-village compensations were necessary. Affected farmers had to negotiate with nonaffected farmers to allow the drain to pass through their lands. For technical reasons, drains may divide farm units or make access to watercourses difficult. In some cases, farmers have refused to join a group, claiming drainage to be unnecessary, despite clear evidence of their benefit. One farmer went to court, arguing that his fields were located at a higher elevation and therefore did not need drainage (ADB, Govt. of Punjab, Director General of Agriculture (Water Management) 1994: 9–20).

For tile drainage schemes, IWASRI favors villages as basic design units and the *union councils*, local provincial government bodies, as management units. Their area of jurisdiction is already about the size covered by a sump drainage unit. They could operate and maintain pump units, organize and execute water distribution, and organize maintenance of watercourses; they may decide on water table depth, monitor water quality, and recommend cycling ratios for the reuse of drainage effluents. However, they should be entrusted with levying water charges to generate their own funds.

A model bylaw for drainage beneficiary groups, proposed by the Pakistan Drainage Consultants, requires that membership of a DBG "shall be constituted by the *drainage users* of the scheme" who would pay membership fees decided by a DBG (Pakistan Drainage Consultants 1998a). Scheme drainage users are upstream farmers, if drainage requirements arise from disposal of excess irrigation water or from rainfall in larger catchments, canal seepage, and high-standing groundwater (Pakistan Drainage Consultants 1998d: 2).[14]

So far, there is no discussion about whether others than ultimate beneficiaries need to join drainage beneficiary groups and contribute to initial and recurrent costs. If only ultimate farmer-beneficiaries bear initial (and O&M) costs, farmers already at a locational disadvantage have to bear costs caused by others. However, group formation for undertaking investments has been easier with ultimate beneficiaries,[15] because of their vital interests in draining a distinct area. But in locations where farmers have migrated,[16] where ownership has changed, and where rivalries among villages, families, religious, or ethnic groups exist (Knops 1997: 108), group formation has been difficult. In the latter case, a solution might be designing small-scale projects, thereby reducing include only one or two villages in a DBG. This conflicts with economies of scale because heavy machinery must be transported to waterlogged areas, raising unit costs.

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14 For instance, the area of the village of Lukhneke is badly flooded by heavy rains, and sheet flow from surrounding villages, located at higher elevations damages its crops (Pakistan Drainage Consultants (1998a): 3).

15 The government's share of cost was about Rs. 64 million; farmers contributed another Rs. 39 million (38 percent of total cost) in terms of labor and land.

16 In Drainage IV project, Phase-II (schedule I), in 6 out of 17 villages, it was impossible to gather 100 percent of the farmers concerned due to migration.

The high number of nonagricultural beneficiaries poses an additional problem. The surface drain Chak 64 RB (Faisalabad district) provides benefit to 5,000 residents in terms of reduced damage to houses, improved health conditions, while 164 farmers benefit from increased productivity and land value (Pakistan Drainage Consultants 1998d). In Drainage IV project (Phase-II), 3,260 farmers and 47,601 residents will benefit from surface and tile drains (Pakistan Drainage Consultants 1998c). Only farmers donated land and provided labor for desilting and remodeling the Nikki Deg main drain (74.6 km) (Sheikhupura/Gujranwala district), but the other beneficiaries are a population of 65,000 and industry which disposes of wastewater (Pakistan Drainage Consultants 1999).

Drainage Beneficiary Groups–Their Organization and Responsibilities

The model bylaw proposed by the Pakistan Drainage Consultants defines a drainage beneficiary group's functions, powers, and the organizational as summarized in (box 4).

Box 4 Proposal of a model bylaw for drainage beneficiary groups

Functions and Powers

- Operation and maintenance of drainage systems
- Conveyance of drainage water to designated disposal points
- Assessment and provision of contributions to development activities
- Assessment, modalities of payments, and collection of drainage charges
- Imposition of surcharges for late or nonpayment of dues; recovery of arrears from defaulters
- Management of financial resources
- Resolution of disputes among members
- Ensuring distribution (if drainage water is fed into deliveries to be reused and to supplement canal water) and removal of water in accordance with locally agreed rules
- Employment of personnel.

The *general meeting* assembles representatives of constituent members; a quorum of at least 50 percent of representatives; makes decisions by consensus or simple majority based on "one member, one vote"; has the right to

- Propose and approve bylaws
- Elect and dismiss management committee members
- Approve accounts
- Schedule seasonal and annual maintenance plans and approve expenditure plans
- Schedule fines and penalties
- Liquidate a group.

The *management committee* comprises the president, treasurer, secretary and six other members (elected by the general meeting); can be dismissed by an absolute majority (two-thirds of the general meeting members); is elected for three years (renewable for one further term); can make decisions by simple majority vote and quorum (four members, including one officeholder). The committee decides whether to pay remuneration, allowance, or salary for performing duties.

O&M is the primary responsibility of the management committee. A DBG will make adequate arrangements to safeguarde sumps and manholes, operate pumps, and clean and repair disposal channels.

The committee has representation in law and vis-à-vis state agencies; manages financial resources (right of signature on bank account) and may enter into contracts.

Source: Pakistan Drainage Consultants (1998a), appendix 1.

Operation and Maintenance by Drainage Beneficiary Groups

Although experience is limited to a few drainage beneficiary groups, interviews with DBG members and field visits point to weaknesses in drainage facility management.

In the FESS project area, the informal drainage beneficiary group appointed a pump operator. Salary payment was its only financial burden since IWASRI provides fuel free of charge. However, operations fell short, because the DBG could not pay the operator's salary due to outstanding debts. Out of 40 DBG-members, 21 did not pay their dues, although their fields were drained. In the absence of legal recognition and registration, the paying members cannot force others to pay, because they cannot approach the juridical system. Exclusion of nonpayers from drainage infrastructure is technically not possible. Other members did not pay their dues, because they had not received water for their fields in the tail reaches. Although water tables beneath their fields dropped, they could not tap into benefits deriving from the drainage scheme.The high number of tenants and absentee landowners also made fee collection difficult.

In the OFWM-assisted and ADB-funded Second OFWM project Dera Ghazi Khan, 10 drains were built in a pilot project (net area drained is 1,240 ha). The impact assessment study mentions that the field outlets for the safe disposal of surface runoff were in poor condition and that the high maintenance requirements in tertiary drains could not be managed (ADB; Govt. Punjab; Director General of Agriculture (Water Management) 1994: 9–17; 9–18). Continuous unmanaged overland flow caused by excess irrigation water supply from adjoining cotton farms at a higher elevation, created deep gully erosion in tertiary drains. Tertiary drains were found badly vegetated, particularly at middle and tail sections, and sediments were deposited in head and middle sections.

In Dera Ghazi Khan, the drains traverse from an area close to minors toward the Kot Adu main drain that has excessive vegetation, bank erosion, sloughing, and sediment deposits, which cause back flows from the main drain into the tertiary drains during floods. The DBG of the surface drain Chak 64 RM constructed gates to control the back flow of rainwater, because the bed level of Maduana branch drain silted up. The same was observed in Dak Nallah into which the DBG Khanna Lubhana drains its pond. The functioning of these drains is negatively affected by poor maintenance of main drains under the PID's SE drainage circles. Similarly, in the Drainage IV project, where water levels in the main drain are too high, the discharged water from the sump remains in the tertiary drain.

Impacts of poor O&M are serious: If tertiary open drainage infrastructure is not adequately maintained, waterlogging may increase in farmers' fields where the surface drains run. While other sections are drained, effluents cannot discharge into drains, creating backwater in these fields. If pumps are not operated, fields near sumps suffer most, because effluent is then channeled through tiles from upper areas downward. Before the tile-cum-sump scheme, effluents moved downward as a sheet; now the upper areas drain faster than before, and water accumulates.

Participatory Approach in Vertical Drainage Schemes

Vertical drainage schemes are provided to lower the groundwater table depth in fresh and saline groundwater areas through the installation of (deep) tubewells. In fresh groundwater areas, the water pumped has been used for irrigation purposes. In some saline areas, the water empties directly into regional outlets, while in others, it is fed into irrigation canals and mixed with good-quality water. Wherever it is used for irrigation, it becomes part of the common pool irrigation water and is subject to common allocation rules and sanctioned discharges. Inequity issues may arise in groundwater abstraction, particularly in the case of overpumping. However, both kinds of vertical drainage schemes provide a local public good to the benefit of agriculturalists as well as nonagriculturalists (urban residents, industry, municipalities).

Depending on natural site specifications, drainage objectives, and social conditions, incentives for farmer participation have been different.

Transfer of Public Tubewells in Fresh Groundwater Areas

Transfer of SCARP tubewells to community tubewell groups (CTWG) started with the mid-term review process of the Second SCARP transition project (SSTP, 1991–97) and continued under the Punjab Private Sector Groundwater Development project (PPSGDP, 1997–2002). Political emphasis on transfer has been to reduce the fiscal burden of O&M cost. It was hoped that private and community tubewells would substitute the water supplied by SCARPs. Groundwater development would compensate deficient canal water supply to increase cropping intensities and yields and maintain adequate water table depth. These objectives could be achieved, as indicated in the project completion report.

The mid-term reviewers of SSTP favored community tubewells over private, because they would result in higher economic gains and improved equity due to higher utilization factors. Community tubewells, instead, would benefit small farmers and curb anarchical and inefficient growth of private tubewells (World Bank 1998: 41–49). The adopted mode of transition so far was regarded to be inequitable, because government subsidies were provided to the private sector, which could afford investment with its own resources. This was indicated by high growth in private tubewells outside the project area. Therefore, the Punjab government discontinued monetary incentives for private tubewells in early 1997 with the PPSGDP in Punjab[17] and provided incentives for communities (see below). Under PPSGDP, more than 2,200 farmer organizations were established for 2,200 community tubewells, community tubewells have substituted for SCARPs in terms of water supply. About 80 percent of the farmers who received water from SCARPs would be the beneficiaries of community tubewells, 85 percent of them small farmers with holdings less than 5 ha.

A second change was related to funding. The Agricultural Development Bank of Pakistan commissioned credits to farmers for tubewell installations. As a bank, its policy was selective: it set the minimum land size for mortgages at more than 2 ha, and it did not consider loans to cooperatives or similar groups. However, cost-recovery rates were low (53 percent), and an International Development Association mission suggested a switch from installments to up-front payments. Although the Punjab government did not support this proposal at that time, it was implemented by the subsequent PPSGDP, and credits were made available for groups. In Sindh, the Agriculture Development Bank of Pakistan provided loans to small farmers if they deposited their passbook as collateral. Loans were granted at 13 to 14 percent interest for a term of 10 years (one year grace period).

Incentives for Transfer to Communities

The Punjab Private Sector Groundwater Development project objectives are to supplement canal irrigation water, to maintain a safe water table depth, to reduce waterlogging and salinity, and to reduce drainage requirements by lining distributaries and watercourses. Community tubewells are favored in areas where the groundwater table depth is within 3.28 m below ground level and surface drains are close and in areas with small landholdings. These conditions are usually met where public tubewells are closed, and few private ones exist. For transfer of SCARP tubewells, the options are:[18]

- A tubewell group takes over *existing SCARP tubewells* as their community tubewell against payment of Rs. 10,000 to the government and a security deposit for electrical connection;

17 The electric network was publicly financed. Tariffs were kept low, and other monetary incentives stipulated that 10 private tubewells might be installed in place of 1 SCARP tubewell.

18 The options differ slightly in Punjab and Sindh.

- Tubewell groups *install new pump equipment on existing boreholes* with a project subsidy of Rs. 20,000, paid in two even installments (50 percent after registration of the group and the balance on completion of civil works);
- Tubewell groups *install new boreholes and equipment* with a project subsidy of Rs. 45,000 payable in two even installments (50 percent after registration of the group and the balance on completion of civil works);
- Private tubewell groups[19] *install new boreholes and equipment* with a project subsidy of Rs. 25,000 payable in two even installments (50 percent after registration of the group and the balance on completion of civil works).

Government spending covers about 50 percent of the cost of an average modified community tubewell and 45 percent of a new one. Farmers are expected to make up the balance. The Board of Revenue of Punjab is responsible for collecting those fees and the water charges. A list of watercourse shareholders with the recoverable amounts is supplied to the deputy commissioners, and collected by the responsible village men (the *lambardar)*. Their share in the initial investments is proportionate to their irrigated land area (Rs. 494 per ha). Investment costs per hectare depend on whether the tubewell supplements canal water or provides all the irrigation water. In the former case, community tubewells can supply water for 60.7 ha, in the latter for about 10.1 ha only. For access to subsidies, farmers must join a community tubewell group and operate and maintain the tubewells out of their own resources.

Group Formation, Water User Rights and Management

Farmers have responded positively to the chance to install new tubewells to replace SCARPs. In August 2000, 90.8 percent chose new installations, 6.6 percent modified SCARPs, and only 2.6 percent took them over. Apart from the monetary incentives given by the government, their main emphasis has been on regaining water supplied by SCARP tubewells. These areas are short of canal water, and groundwater is regarded as an important supplementary source of about 60 percent of irrigation water (there, 67,110 private tubewells operate). However, SCARP tubewells were inoperable for many years, and when their closure was publicly announced, farmers agreed to cost-sharing arrangements and committed to O&M obligations. In case of financial constraints, some members, usually chairmen, paid seed money. These advances were to be repaid after harvest, but were not always (appendix D).

Farmers who wanted to establish a group and manage a community tubewell, had to interpret legal regulations. The Water Users Association Ordinance (1981), the basic document for the establishment and registration of farmer organizations until 1997, did not foresee tubewell groups, but associations at watercourse level. The WUA Ordinance originated in efforts at watercourse lining. The WUA ordinance requires a minimum membership of 51 percent of eligible water users on a respective watercourse for registration. It has been interpreted that if 30 percent of WUA members apply for tubewell drilling and subsidies and accept the obligations, a community tubewell group can be established. This has created pressure on needy farmers to involve companions later identified as “inactive” or “proxy” members.

Water user rights to tubewell water are restricted to group members, and relate to the share of initial contributions that are paid according to the area irrigated. Only if group members agree, do additional users have access. User rights of the CTWG-members come first, nonmembers are second in line. They pay higher charges per time than member farmers, Rs. 45 per hour as compared to Rs. 31 per hour.

Latif and Masih (2000), who assessed the sustainability of community tubewells, show that one quarter of the original group members do not receive water due to some farmers’ monopoly position. This is predominant where the sump is located on the holding of the farmer who has paid all or a major share of

19 In private tubewell groups, individuals representing families sign the contract and act on their behalf.

the seed money and who is an officeholder. Land should either be sold to community tubewell groups (which rarely happened), or landowners would sign agreements not to exploit their locational advantage. Instead, 80 percent of registered members were deprived of their rights to use the facility; in a PPSGDP area this share was one quarter of the original group members. Other registered group members do not receive water because they joined as proxies (10 percent) or later became later "technical knock-outs" (16.5 percent), i.e. farmers who initially were part of the scheme but did not receive water from the tubewell for technical reasons. A few community tubewells delivered saline water; others discharged into the watercourse downstream of the members' outlets. Seven percent of the CTWGs did not exist at all; 45.71 percent are in full control of one farmer. Groups with four and more members are rare (11.43 percent), and in all cases are close relatives. It was reported that water allocation would not be fair among members. Many members have not irrigated their fields even once since the installation of the community tubewell. Only influential farmers received reliable and adequate water supply. Few tubewells are professionally operated, and only few farmers actively participate in maintenance and repair.

A CTWG has a chairman, a secretary, a-treasurer, and a water manager who is in charge of operation and maintenance. Farmers apply for water to the water manager who notes the date and duration time. A group is expected to deposit the equivalent of one (6-month) season of O&M costs in its bank account. However, farmers refused to deposit money, fearing misuse of money. A group's informal position would make legal actions against defaulters difficult. In contrast to the PPSGDP proposal, CTWGs decided on different rules for financing operation costs.

- If pumps are *electricity driven*, charges are paid against time recorded by water masters. Water extraction by pumping is permissable only if costs are paid in advance of water deliveries**.** Groups with electrical pumps need a joint bank account to which only the president and the treasurer have access. Current expenses are documented, and each farmer has access to the file.
- *Diesel-driven* pump sets require less sophisticated monitoring and control mechanisms: Tubewell users are required to fill the diesel tank after operation. This can be easily monitored by the next user: the tank is full or not. However, no qualified operator was found, and maintenance activities are undertaken on demand. Only a few groups collect a nominal amount for maintenance (Rs. 15 per hour to Rs. 20 per hour for routine maintenance).

Drainage Tubewells, Scavanger Wells and Interceptor Drains

Participatory approaches for drainage tubewells, scavanger wells, and interceptor drains failed because of their salient features (Govt. of Pakistan, Water and Power Development Authority 1998: 3-1–3-4).

The areas drained by drainage tubewells and scavanger wells can not be clearly marked on the surface, and there is an indistinct subsurface hydraulic interface between adjacent wells, making the identification of beneficiaries difficult. Their diffuse boundaries and the sheer size of the areas to be drained (>500 ha) do not encourage the establishment of groups. Farmers whose land is close to the notional boundary of a drainage well are unlikely to fulfill a responsibility for maintaining a disposal channel carrying effluents to a subdrain miles away. In the case of scavanger wells, which skim usable groundwater and pump saline groundwater from deeper layers, disposal channels transport the usable groundwater to watercourses far from the well. Thus, because of the multiplicity of groups of benefiting farmers operation of the scavenger wells and maintenance of the disposal channels is troublesome: one group enjoys the freshwater, and another group's lands are drained.

Where interceptor drains are installed to eliminate or reduce seepage from canals and thus reduce waterlogging in adjacent areas, definition of hydraulic boundaries and identification of beneficiaries is equally difficult. Seepage water drains into a sump through tile drains extendiing more than a kilometer on either side of the sump. This water is pumped back into the canal to provide supplementary irrigation water for downstream farmers. Again, depending on the alignment of the disposal channel, there may be two distinct groups of benefiting farmers.

Pilot projects have shown that farmers have no interest in taking over drainage tubewells in the saline groundwater areas. These remain, so far, under the command of the PID, SE SCARP in Punjab and under SIDA in Sindh. These tubewells serve only drainage purposes and cannot compensate deficient canal water except in places without a nearby drain. There, drainage tubewells discharge into distributaries or minors, and water is reused for irrigation.

In the SCARP-II area, Sarghoda district, where the main Raniwah Drain (48 km) intercepts between the fresh and the saline groundwater area, 70 drainage tubewells will be installed to stop the gradient and arrest inflow of saline water from the saline zone into the fresh zone. Ten tubewells will be installed along Sikandarpur Branch Drain, the rest along the Raniwah Drain (PPSGDP 1998a). Due to pumping in fresh groundwater, saline water intruded. The drainage tubewells will also maintain water table at an appropriate depth. SCARP tubewells have been operated in this area since 1966, and some of the wells have gradually become saline due to lateral and vertical movement of saline groundwater into the freshwater aquifer. There is evidence that this has already affected the operation of about 250 tubewells in the vicinity, and some of them are no longer operable. Project consultants approached farmers whose fields are in the saline zone but close to the main drain, to form a CTWG. The farmers' fields located alongside the main and branch drains are partly waterlogged because the water table is only 1.5 m to 3.3 m below the soil surface. The high initial costs would cause no difficulties because of government subsidies. Nevertheless, the affected farmers did not join a group, possibly for the following reasons. Potential beneficiaries belong to seven villages and are supplied by many watercourses. Group formation between different villages and watercourses, and their high number, appeared to be difficult. If the drainage tubewells achieve their objective, they will mainly benefit farmers in the fresh groundwater zone, because saltwater intrusion is prevented. However, the group operating the tubewells would have no power over these farmers (contribution to O&M costs).

Experiments in Sindh are particularly noteworthy. The Drainage Advisory Service initiated the establishment of more than 100 DBGs that did not last long (Govt. Sindh, Irrigation and Power Department 1998). Thereafter, the advisory service proposed two organizational models to overcome these difficulties: the large farmer model and the mixed farmer model (Govt. of Pakistan, WAPDA 1998: 4-8–4-12). These models were based on landholdings and social boundaries rather than on hydraulic boundaries.

The *large farmer model* would comprise the fields of one clan on which a number of tubewells are located. These lands would form a tubewell zone. Within a tubewell zone, each tubewell would have a nominal leader, a close relative of the clan leader who would be responsible for O&M. This model takes advantage of social ties that are reinforced by holding titles to the land on which the tubewells are located. However, this model does not serve equity concerns, since dependency on large farmers runs the risk of ignoring or excluding the interests of small owners, tenants, and laborers.

The *mixed farmer model* indicates social heterogeneity comprising different tribes and castes who own land and live in mostly amicable circumstances. Whether these farmers will cooperate to manage a tubewell zone is dubious, since caste rivalries and disputes between social groups are part of the fabric of Sindh society. While the large farmer model was successful in one area only, the landholding of the Gorchani clan, the mixed farmer model could not be implemented.

In light of these experiments, it would seems more realistic for the irrigation and drainage authorities and the area water boards to take over O&M of drainage and scavanger tubewells and interceptor drains and to charge the benefiting farmers for these services. Private contractors, farmer organizations, or public agencies may operate and maintain the facilities under performance contracts (PPSGDP Management Unit 2000).

Conclusions

Experiments with participatory approaches to drainage at the micro level have shown mixed results (table 7). Cooperation among the farmers affected by waterlogging and salinity has not been readily forthcoming, but successful cases show a dstinct correlation between cooperation and the drainage technology selected and its objectives, the scale of the drainage schemes, and the ease of identifying beneficiaries, as well as social criteria and social mobilization efforts.

In Punjab, farmers joined drainage beneficiary groups at tertiary open drains. Since the DBGs comprise farmers that are most affected by ponding and waterlogging, their common need has been a great incentive to form groups and contribute to the required initial investment shares. Still, DBGs had to arrange with nonmember landowners if drains cross their land. In some instances, drain construction was problematic if small holders could not afford to donate land, but arrangements among farmers solved the problem. However, drainage beneficiaries may outnumber the “ultimate” beneficiaries. This raises concerns not only about fairness but also about the organization’s financial sustainability.

Although identifying beneficiaries of tile drainage schemes is less difficult, group formation and contributions toward investment have been more difficult because of the high cost involved. However, success has been achieved in the FESS area, largely attributable to social mobilization efforts and facilitated credit. The groups have taken over O&M on cost-recovery basis.

DBGs are established as organizations separate from irrigation management. In terms of power and authority (collection of charges, enforcing sanctions), they weaker than irrigation organizations that control the important input—irrigation water. Importantly, benefits from drainage schemes can be realized only if water supply is guaranteed. This reemphasizes the urgent need to link drainage management with improved irrigation system management. With evolving farmer organizations, this issue requires due consideration. There is concern, however, that a farmer who must participate in more than one organization, for example, a drainage beneficiary group, a community tubewell group, and a watercourse association, faces high opportunity cost in terms of information gathering and participating in decisionmaking, which may affect organizational sustainability.

In addition, coordination has been problematic between DBGs, either on open or tile drainage schemes, and the organizations responsible for managing the next level of drainage infrastructure, the PID’s drainage circles. Again, farmer organizations at watercourse command level would be the ultimate organizations coordinating and supervising drainage management.

Replacement of SCARP tubewells in fresh groundwater areas by community tubewells has been successful. Reasons are that farmers expect to increase irrigation water availability. However, long-term sustainability of community tubewell groups depends on whether regulations can be designed and enforced to benefit all users of an aquifer, whether transparent water allocation rules can be defined and enforced, and whether financial sustainability can be achieved for operation and maintenance.

Initiatives to establish drainage beneficiary groups at drainage tubewells, scavanger wells, and interceptor drains have failed, and farmers have shown no interest in taking over these drainage technologies. Major reasons are that farmer did not identify themselves as beneficiaries because of invisible hydraulic boundaries. It is not yet decided whether approaches in Sindh, based on landholdings and social boundaries rather than on hydraulic boundaries, promise better results, or whether these facilities should be managed by area water boards and farmer organizations.

Table 7 Drainage technology and participatory management organizations

Drainage technology/ hydrological specifications	***Organizations for management at micro level***	***Comments***
Deep tubewells in saline groundwater areas		Experiments to establish drainage beneficiary groups (DBGs) and to turn over management failed.
Deep tubewells in fresh groundwater areas	Community tubewell groups (under 4 transfer options)	Water allocation among farmers is critical. Sustainability depends on aquifer management and on maintaining drainage.
Shallow tubewells infresh groundwater areas	Private and community tubewell groups	Water allocation among farmers is critical. Sustainability depends on aquifer management and on maintaining drainage.
Tile-cum-sump drainage schemes	DBGs in the FESS project area	Failed in Drainage IV project area.
Interceptor drains		Experiments with DBGs and management turnover failed.
Scavanger wells		Experiments with DBGs and management turn over failed. Yet to be tested: large farmer model, mixed farmer model.
Tertiary open drains, watercourse escapes, Disposal channels from sumps	DBGs	Problems relate to authority and power, financing, main drainage system management.

FESS Fordwah Eastern Sadiqia (South) Irrigation and Drainage project.
Source: Authors’ compilation.

7. Institutional Reforms in Pakistan's Irrigation and Drainage Sector

During the 1980s, the On-Farm Water Management projects I & II and the Command Water Management Program introduced farmer participation in irrigation management on a limited scale. For the first time, it was realized that improved irrigation management requires not only infrastructure interventions but also institutional-managerial changes. The recognition that these early innovations had not been sustainable, prompted donors and policymakers to seek a comprehensive institutional approach during the 1990s. In 1994, the World Bank claimed that an all-encompassing new legal and institutional framework was needed to overcome significant deficits in financing, operation, and maintenance of the Indus Basin irrigation and drainage systems.

In 1997, almost all the provincial assemblies approved the Provincial Irrigation and Drainage Authority Acts, and by the end of year, the government of Pakistan and the multilateral group of lenders finally agreed on the first phase of the 25-year National Drainage Program. In October 2002, Sindh province issued the Sindh Water Management Ordinance (SWMO), more comprehensive than the previous Sindh Irrigation and Drainage Authority Act (1997). Funds for the four NDP components—drainage sector planning and research, institutional reforms, investment; and program coordination and supervision—were to come from the International Development Association, the Japan Overseas Bank for International Cooperation, the Asian Development Bank, the government of Pakistan, the provinces, and farmers.

Meanwhile, the country is undertaking unique efforts to restructure its irrigation and drainage sector in terms of

- Infrastructure investments, particularly in the drainage sector, to provide a comprehensive and technically integrated drainage system based on a drainage basin approach
- Institutional innovations that show a strong emphasis on devolution and creating autonomous, self-financing, and self-accounting entities
- Integrating environmental policies into the irrigation and drainage sector to improve the sustainability of irrigated agriculture, protect freshwater ecosystems, and prevent groundwater overexploitation and depletion.

The following sections briefly introduce the new drainage strategy, and discuss, in more detail, the institutional components that aim at developing sound management structures to effectively integrate drainage into water resources management. Issues of concern are how participatory drainage management approaches may become an integral part of the institutional setting, and how financial sustainability can be achieved for drainage service provision.

A New Drainage Strategy: The Master Drainage Plan and Drainage Accord

Achieving self reliance with respect to the country's drainage sector by relying on and developing local capacity

- Changing the country's project implementation strategy to avoid spreading meager financial resources over too many projects
- Developing a Master Drainage Plan including a National Surface Drainage System, based on an intra-provincial accord

- Developing alternative arrangements for O&M budgeting procedures, promoting farmer participation, and imposing a drainage cess
- Improving land reclamation by applyinig all drainage technologies available
- Managing aquifers according to a comprehensive groundwater regulatory and monitoring framework to guide the private and public sectors and implementing water conservation measures
- Disposing of effluents and salt outside the basin in accordance with the National Effluent Quality Management Plan to be developed in consultation with the Ministry of Environment.

The new drainage strategy takes a comprehensive approach to the drainage problem so as to overcome the handicaps of the former piecemeal strategy of isolated projects. The new strategy is based on the identification of drainage basins and subbasins throughout the country. The major objectives agreed in the National Drainage Program are: to minimize drainable surplus and to facilitate the eventual evacuation of all saline surplus from the Indus Basin to the Arabian Sea. A national Master Drainage Plan financed under the National Drainage Program, would cover surface and subsurface drainage, salt management, drainage of stormwater, disposal of treated municipal and industrial effluents for every basins in the country. The final plan will include a legal framework for cost sharing and operation among the provinces, the federal government, and WAPDA, a financial plan, and environmental aspects.

The overall objective of the Master Drainage Plan is to develop an environmentally safe plan for evacuating the saline drainage surplus and polluted industrial and municipal effluents from the basin by a system of interconnected federally owned and operated outfall drains. To that end, an ambitious Basin-wide Environmental Management Program and a Water Sector Environmental Management Plan have been set up to correct for the lack of environmental activities (Pakistan Drainage Consultants 2002a; 2002b). Moreover, the Master Drainage Plan will take into account the rehabilitation and augmentation of the existing drainage systems and promote investigations into ways of reducinig the drainage surplus. The Master Drainage Plan includes the preparation of a basinwide drainage atlas covering existing and planned drainage facilities in each basin. Its overall outcome would result in an environmentally sound drainage network to regulate salt balance in each basin.

To facilitate these objectives, two studies are underway, the Prefeasibility Study of a National Surface Drainage System and the Soil and Waterlogging Surveys of Irrigation Areas. Meanwhile, a panel of international and national experts in drainage, water, and environmental management has reviewed the NSDS Prefeasibility Study and made major recommendations in preparation for the next phase of the report (Pakistan National Surface Drainage System (NSDS), Panel Consultation Review Report 2002).

A new regulatory framework for groundwater development and use has been proposed under the Punjab Private Sector Groundwater Development Project. The National Water Quality Monitoring Program and new standards for irrigation water quality will provide the basis for developing site-specific operational guidelines. Both efforts are essential contributions toward an integrated approach in the water sector.

The Institutional Hierarchy for Irrigation and Drainage

The World Bank's proposals for a radical reorganization of the entire sector—including irrigation management turn-over to farmer organizations, the establishment of autonomous public utilities, and the legal facilitation of water markets—met with considerable resistance and skepticism among Pakistan's irrigation managers and government officials (Van der Velde and Tirmizi 1999; Scheumann 2002). Seeking to win support for the reform process, the debate among policymakers, donors, and experts shifted toward the concepts of decentralization and participatory irrigation and drainage management, from provincial irrigation departments to a multitier system of autonomous institutions. The hierarchy of institutions, their functions and responsibilities for irrigation and drainage is designed as shown in table 8 (Wambia 2000) and in the list below.

- Decisionmaking at policy level shifts from federal to provincial level. A comprehensive national Master Drainage Plan, encompassying the national surface drainage system, would be based on an interprovincial drainage accord.
- The role of WAPDA's Water Wing would eventually be limited to interprovincial functions such as operation and maintenance of interprovincial drains.
- Provincial irrigation departments would be converted into autonomous provincial irrigation and drainage authorities. The Provincial Acts gives them the authority to control all rivers, canals, drains, streams, hill torrents, public springs, natural lakes, reservoirs (except those under WAPDA), and groundwater resources. They are responsible for the intraprovincial drainage aspects of the system from barrages to canal headworks, and from main drains that cross canal commands and major drainage basins, to interprovincial drains operated and maintained by WAPDA.
- The authorities would plan, design, and construct drainage infrastructure; manage drainage effluent within their jurisdiction; decide on a drainage cess in consultation with the provincial government; issue rules for groundwater development and use. The Sindh Irrigation and Drainage Authority (SIDA) has already taken over the spinal drain and small drains located mostly in the Nara Canal Command Area. SIDA has decided to levy a drainage cess of Rs. 247 per ha per year, to be gradually implemented in the LBOD area.
- Self-accounting area water boards, initially set up as pilots, would be established around selected canal commands to take over and manage the irrigation and drainage systems from canal headworks to distributaries and minors operated by farmer organizations, and from nodal points into which subdrains (<15 cusecs) discharge, operated by farmer organizations, to main drains operated by IDAs.
- Farmer organizations are encouraged through a series of pilots in the area water board command areas to take over and manage the irrigation and drainage system at distributary and minor level, including subdrains (<15 cusecs); receive drainage effluents from its members and convey it to nodal points designated by its AWB; settle disputes over water allocation; determine the basis of assessment and rates for irrigation and drainage charges to be levied on its members and the payment modalities, and collect such charges. A 60 percent share of the water charges collected would be paid to AWBs. However, these charges are supposed to be reviewed every year under the irrigation management transfer agreement.

Governing Agricultural Drainage

Responsibilities for drainage management have been roughly defined for all levels (table 8). Implementation depends on the overall progress in creating the new institutional setting. Punjab province follows "a very cautious and gradual transition of PID into IDA, AWBs and farmer organizations instead of abrupt decentralization." It argues that "any attempt to change the system overnight will result in anarchy, inequitable distribution of water" (NDP, Punjab (no year): 1). Punjab has set up only one pilot Area Water Board in the Lower Chenab Canal, and only three distributary commands were transferred to farmer organizations. In Sindh province, progress is more pronounced: 5 Area Water Boards have been established in Nara Canal, Sindh Beghari Feeder Canal, Ghotki Feeder Canal, Left Bank Circle (Phuleli and Akram wah canals), Western Sindh (Rice and Dadu canals); more than 50 distributary commands have been transferred to farmer organizations, and almost 150 farmer organizations have been established (Memon and others 2000). However, critical governance and management issues still need due consideration.

Table 8 The multilevel/multiorganizational arrangement (IDA Reform)

Policy	*Federal level* *Ministry of Water and Power, govt. of Pakistan*	*Provincial and local level* *Provincial Irrigation and Power Dept.; Planning and Development Dept. and Board in Punjab*
O&M and financing		
Interprovince surface drains	Water and Power Development Authority (WAPDA)	
Intraprovince surface drains		
▪ Main drains		Irrigation and drainage authorities
▪ Branch drains		Area waterr boards
▪ <15 cusec drains		Farmer organizations, drainage beneficiary groups
▪ Disposal channels		Farmer organizations, drainage beneficiary groups
Tile drainage		
▪ Operation (electricity)		Farmer organizations, drainage beneficiary groups
▪ Maintenance, guarding		Farmer organizations, drainage beneficiary groups
Vertical (tubewells)		
▪ Saline groundwater		Area water boards
▪ Community tubewells		Community tubewell groups
▪ Private tubewells		Individual owners, groups
Water management		
▪ Rivers	Indus River System Authority	Irrigation and drainage authorities
▪ Barrages		IDA
▪ Main and branch canals		Area water boards
▪ Distributaries/minors		Farmer organizations
▪ Watercourses		Farmer organizations
▪ Lift channels		Farmer organizations
▪ Groundwater		Area water boards
Water quality		
▪ Irrigation water		IDA, Area water board
▪ Drainage effluent		IDA, Area water board
▪ Industrial effluent		Environment Department, industry
▪ Municipal sewerage		Legally not yet decided
Technical support for farmer organizations		Provincial Agriculture Department (OFWM), Area water boards
Land reclamation		Not yet decided

OFWM On-Farm Water Management of Provincial Agriculture Department.
Source: Authors' compilation.

Area Water Boards at Canal Commands

The management areas of the area water boards are initially canal commands. To improve water management including drainage, it may be advisable to extend an area water board's jurisdiction to encompass drainage basins or subbasins. Drainage investments in conjunction with ongoing restructuring and remodeling of irrigation and drainage infrastructure might facilitate the creation of consistent units. The framework for groundwater management has defined groundwater management areas and "critical areas" within them as units for observation and management to see that their boundaries are consistent with the physical boundaries of irrigation canal command areas, since 80 percent of groundwater recharge comes from seepage of irrigation canals.

Where drainage basins or subbasins are the basic units for managing water and roughly coincide with irrigation command areas and groundwater management areas, irrigation system management can reduce drainable surplus within such an entity by controlling surface and groundwater use. Where this can not be achieved, for instance, where surface drains cross more than one canal command area or where more than one area water board share a single groundwater aquifer, need for coordination and cost-sharing arises.

Groundwater management would eventually include tubewells in saline groundwater areas to satisfy drainage requirements. Drainage tubewells may be either be managed directly or supervised under contract, by an area water board

Groundwater management faces the challenge that groundwater use is in the private sector (including community tubewell groups). Long-term sustainability of groundwater use depends on whether regulation can be designed and enforced to benefit all users of an aquifer, be they community or private tubewell groups; whether transparent water allocation rules are defined and can be enforced; and whether they can achieve financial sustainability for operation and maintenance. The Punjab Private Sector Groundwater Development project drafted a groundwater regulatory framework to promote optimal management and development of groundwater resources in the province. Guidelines for interventions will be specified for different zones such as shallow, deep, saline, and fresh groundwater areas. Groundwater management units within area water boards will be responsible for registration, granting licenses, withdrawal, closure, and, in case of infraction, levying fines for unauthorized use. Institutional solutions to sustainable groundwater management posescomplex issues of equity and choosing the best means of developing and implementing desirable policy interventions to regulate groundwater overdraft. It is estimated that in the next 25 years the area out of reach by poor farmers will grow to 20 percent, if the present rate of growth of groundwater withdrawals in fresh groundwater areas cannot be stopped. However, it is early in the process, and precise data are lacking on the number of wells, actual extractions rates, and water quality. Sindh province has not yet envisaged a regulatory framework due to the limited amount of fresh groundwater (20 percent).

Of further concern is whether the operation of the many private wells is in accordance with drainage requirements and the net groundwater recharge in the individual areas, and not only with crop water requirements, which may change from year to year depending on rainfall and canal water supplies.

Unanswered questions remain with respect to managing the whole array of drainage, crucial governance issues at the level of the area water boards. They are:

- What kind of organizational unit should take over the responsibility of the SE drainage circles/project directors?
- Who decides how much drainage service to provide and who monitors performance?
- How can the long-term neglect of drainage by provincial irrigation departments be overcome?
- How do agricultural users and nonagricultural beneficiaries share O&M costs, and where is the organizational nexus to discuss the divergent interests of different stakeholders?

Water quality issues are by no means easy to implement. Although a new classification for irrigation water quality has been recommended (appendix C, table C2), there is no technical network to monitor water quality effectively, be it surface or groundwater. Nor are there any operational rules, and no decision has been made about which organizational unit will monitor and implement the yet to be developed operational rules.

Since drainage management with its many aspects and its integration into water and irrigation management is becoming increasingly complex, a sound knowledge base is needed. For instance, management measures of groundwater have to be site specific, as no blue print for addressing the problems in all areas will fit. Applied research can support and ease management decisions, and advisory committees/panels may assist area water boards. Experience with existing research institutes suggests that closer links must be established between decisionmaking units and research, not only at the province level but also for canal commands and drainage subbasins.

Farmer Organizations at Distributary Level

Farmer organizations are expected to manage irrigation and drainage within the distributary command areas (figure 2). The establishment of drainage beneficiary groups is promoted which eventually would manage the respective drainage facilities, the open off-farm drainage infrastructure and tile drainage schemes. Their relation to farmer organizations has yet to be defined, because who assigns responsibility for drainage management within the farmer organizations has not been determined.

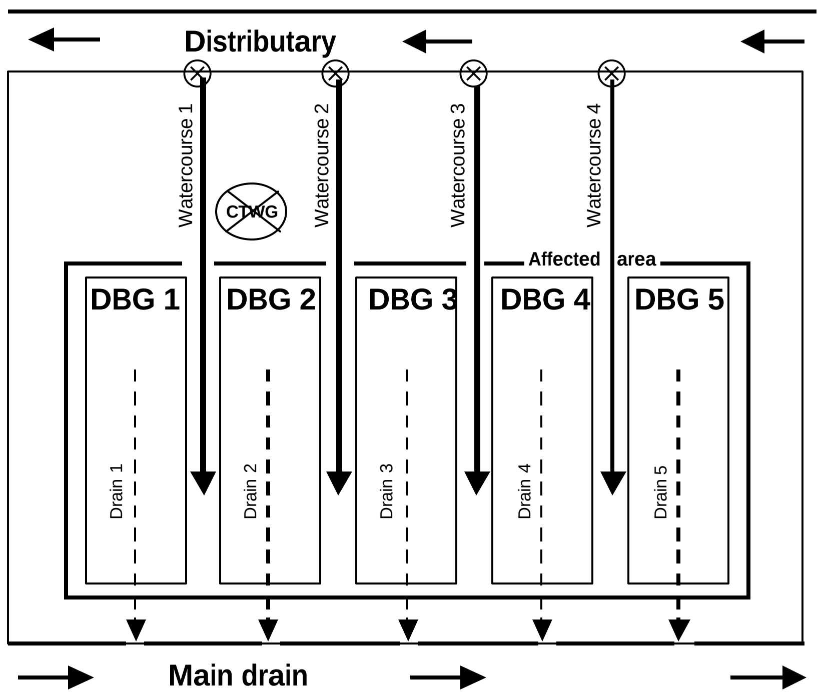
Drainage beneficiary groups have been established as organizations separate from irrigation management. The Sindh Water Management Ordinance (2002) mentions that drainage beneficiary groups will be formed under the auspices of farmer organizations, and that DBGs are responsible for drainage management in their respective jurisdictions. However, clarification is needed: Will they have the authority to collect charges and enforce sanctions, and since they have no control over the important input, irrigation water, what kind of authority? Do the most affected farmers have a voice of their own in a farmer organization's decisionmaking, similar to the irrigation regulations, where the the bylaws of farmer organizations assure the most disadvantaged tail-end farmers representation on the management committees (SIDA 2000; Govt. Punjab, Irrigation and Power Department 2000)? It may be appropriate for the evolving farmer organizations to establish a drainage group as a part of their management committee either to organize or supervise drainage within their distributary command areas and to coordinate with adjacent farmer organizations, because drainage beneficiary groups are limited to tile drainage schemes and maintenance of watercourse escapes and smaller tertiary open drains. The technical managers to be employed by the farmer organizations would need skills in drainage as well (PIDA 2000: 9–10).

Empirical evidence suggests that coordination has been problematic between drainage beneficiary groups, either on surface or tile drainage schemes and the organizations responsible for managing subsequent levels of drainage infrastructure. Attention should be devoted to assigning functions and defining responsibilities.

Financing Drainage Services

Drainage infrastructure is dilapidated because maintenance has been put off mainly due to budgetary constraints. In the next few years, budgetary allocations will be further curtailed since the National Drainage Program is firmly committed to phasing out O&M subsidies. Eventually, a drainage cess will be levied to raise enough money to operate and maintaini off-farm drainage infrastructure. So far, no decision has been made on how to generate funds, how to calculate a cess, or to what extent the farming community and nonagricultural beneficiaries will be charged.

Figure 2 Command Area of a farmers' organization with drainage beneficiary groups and community tubewell groups



Source: Authors.

A study conducted by the Sindh Development Studies Center (1995) shows a general awareness among landowners of the benefits of drainage and a *willingness to pay* a drainage cess. The majority of respondents were willing to contribute cash or labor toward the O&M costs, of drainage provided that they get irrigation water. Since this is not always the case, they cannot benefit from drainage systems. The farmers interviewed made some suggestions as to how a drainage cess might be calculated:

- Farmers who cultivate large tracks of land at the head reach of irrigation canals should pay a higher drainage cess because they are assured of a supply ofirrigation water and therefore benefit most from drainage systems.
- A drainage cess should be a fixed rate calculated on a per hectare per season. Such a simple rate would be easy to collect and would reduce malfeasance (underreporting of *cropped* area by some farmers).
- A drainage cess should be categorized into several tiers for social reasons (small holdings), and higher rates should be levied on large holdings.

There is some resistance among the farmers who already pay water charges, land revenue taxes, productivity taxes (agriculture tax), local fund tax, and, in some districts, a council tax. These taxes are collected, if ever, by revenue departments and deposited into the provincial government's exchequer. With respect to the farmers' *ability to pay*, for major crops the current composite taxes (water charges, land revenue taxes, productivity taxes, and local fund rates) as percentage of their net return are as follows: for wheat, 5.6 percent of the net return; for cotton 9.5 percent; for rice 7.2 percent; for sugar cane 4.6 percent; for fodder 1 percent; and for oilseeds 8.4 percent. Actual payments are always lower than assessments, and there is considerable concern that big landowners and cultivators evade payment through political connections and side-payments to revenue officials.

However, as parts of the drainage network serve a multiplicity of beneficiaries, it seems useful to define a share that can be recovered by direct beneficiaries (e.g., farmers, industry, municipalities), and the share federal and provincial governments may contribute (e.g., for flood control through large storm-cum-seepage drains, protection of roads and railways). In Sindh province, for example, the stated objective is to recover 65 percent of all O&M costs from farmers, the government and nonagricultural beneficiaries paying the remainder. Since industry, municipalities, and rural settlements use the drainage network, they should contribute toward maintenance costs (polluters-pay-principle). At present, only industry is charged, based on the volume of effluents released irrespective of their composition (i.e., active substances). Prior to the establishment of irrigation and drainage authorities, provincial irrigation departments granted rights to use drains. They were expected to check the volume of effluents while the Environment Protection Department would control quality. Regulation standards exist, and pretreatment is required if effluents do not meet the standards. In case of noncompliance, the highest fine is closure of plants. However, monitoring and enforcement is poor, and the collection rate is unknown. The present charge for industrial effluents of Rs.11,000 per cusecs per year (Punjab) needs to be upgraded, at least to the level that civil authorities levy (Ul-Haq 1998: 116–18). Finally, decisions are to be made about who collects pollution charges, who may use them, and for what.

Because seepage from link canals, for example, significantly contributes to high groundwater levels while transporting water over distances to remote canal command areas, they create drainage problems whereas the benefit from this water is obtained somewhere else. Therefore, a certain amount per hectare ought to be levied from all farmers within command areas. For the farming community, a uniform cess would be advantageous in terms of assessment and billing procedures, because it reduces administration costs. If socially desirable, small landholdings could get reductions, and discounts for prompt payment could be provided. At the same time, a system of enforceable penalties on nonpayers is needed, taking social issues into account. The Sindh Development Studies Center has proposed that no cess and no tax should be collected in the case of total crop failure.

The study of the Sindh Development Studies Center also shows that financing drainage services is closely related to improved irrigation system management. Equally important is the development of efficient management structures with professional skills for drainage at each level (farmer organization, area water board, irrigation drainage authorities) and that every effort must be undertaken to prevent malfeasance that causes undercollection of charges (Ul-Haq 1998: 119).

8. Conclusions and Recommendations

The Pakistan case shows that long-lasting failure to provide a technically comprehensive drainage system has cost the national economy dearly in terms of land losses, yield reductions, and loss of income opportunities. Recycling low-quality water within the basin and using it for irrigation has caused secondary salinization and sodification of soils, increasing the cost of land reclamation. Despite this disappointing picture, there are success stories as, for example, in the FESS , Drainage IV, and LBOD project areas where drainage facilities have benefited the many small farmers.

The drainage technology applied for decades—deep SCARP tubewells—proved unsustainable both for financial reasons and for maintaining safe yields in the aquifers. With respect to the relation between drainage technology and site specifications, a major distinction was made between fresh and saline groundwater areas (water can be used or not for irrigation), but interventions by no means followed a comprehensive plan and were implemented in isolated projects without major regional outlets to dispose of saline effluents. Investment needs are high, and applying nonstructural means, managerial and economic, might reduce drainable surplus. Further investigation is needed to determine whether a typology of drainage interventions that includes appropriate drainage technologies can be developed for the major agroclimatic zones defined under the Revised Action Program for Irrigated Agriculture in 1979.

Meanwhile, Pakistan's policy is moving toward integrated management of water resources that encompasses surface and groundwater, salt management, agricultural drainage including removal of stormwater, disposal of municipal and industrial effluents, and water quality control. Planning and management will rely on major drainage basins, or subbasins as basic units, designed to serve groundwater management areas and irrigation canal command areas simultaneously.

However, there is no doubt about the enormous challenge confronting Pakistan in implementing the new drainage strategy and movinge toward integrated water resources management, a strategy that has been evolving in developed countries over decades, not years, and is not yet complete. Meeting this challenge entails restructuring the whole irrigation and drainage sector, realizing a technically comprehensive drainage system, implementing sound practices for managing surface and groundwater, and taking due consideration of nature protection and health concerns. But by far the most challenging task will be transforming and stabilizing the institutional setting.

Governing structures for managing agricultural drainage are yet to be developed, and they will not automatically develop as a by-product of the evolving farmer organizations. The management areas of the irrigation system coincide with the jurisdictional areas of farmer organizations, whereas drainage basin and subbasin boundaries might cross the command areas of several farmer organizations.Drainage units or groups should be established at all management levels. With respect to the whole array of drainage infrastructure, there is concern about finding ways to ensure that maintenance receives proper attention. Effective management units for drainage are needed, but their evolution depends on the overall progress in creating new institutions as envisaged in the Provincial Irrigation and Drainage Authority Acts. As can be seen, the process of institutional reform takes much longer than official documents might suggest and ultimately requires social mobilization efforts on a regular basis, based on unambiguous support from donors and political decisionmakers. The increasing complexity of tasks demands skilled personnel at every level and a sound knowledge base with close links between research institutes and decisionmaking units.

Community and private tubewell groups successfully replaced SCARP tubewells in fresh groundwater areas. Subsidies and credit facilities promoted group formation. However, long-term sustainability of these groups depends on the achievement of recurrent cost recovery and the development and enforcement of transparent water allocation rules to maintain a safe yield in the aquifers and to prevent saline water intrusion. An issue of concern is whether the operation of the many private and community tubewells are also in accordance with drainage requirements and the net groundwater recharge in the individual areasm—and not only with crop water requirements, which may change from year to year depending on rainfall and canal water supplies. As developed in Punjab, Sindh requires a regulatory framework for groundwater management.

Participation in drainage management at lower levels has shown mixed results. Drainage beneficiary groups at tertiary open drains can be replicated in similar situations but need support in planning, designing, and constructing drains and facilitating credit conditions. Their sustainability depends foremost on whether members of these groups get their sanctioned share of water so as to benefit from their drainage investment. In this respect, their relation to farmer organizations requires due attention. Drainage beneficiary groups at tile-cum-sump schemes were established in the FESS project area through social mobilization efforts and favorable credit conditions. But experiments in the Drainage IV project area failed because of the high costs involved.

Generating sufficient revenue taking due consideration of social issues and preventing malfeasance with the charges collected are major challenges. If area water boards fail to provide adequate irrigation services, farmer organizations can withhold from the area water boards a share of the water charges collected as a "penalty." A similar arrangement could be discussed for failure to provide drainage services. A uniform cess per area irrigated per season would be advantageous in terms of assessment and billing. In addition, a certain amount may be levied on all farmers using irrigation water because seepage from link canals, for example, significantly contributes to high groundwater levels while transporting water over long distances, thus creating costs whereas benefit from water is obtained elsewhere else.

Since a drainage network serves multiple purposes, direct beneficiaries (farmers, industry, municipalities) must share in the cost, while the federal and provincial governments will finance public goods such as flood control, protection of human lives and assets, and improved health conditions. For social reasons, small holdings could get reductions. This also raises the institutional issue of coordination and cooperation among different stakeholders and negotiation of conflicting interests.

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Appendix A. Field Program

The field program was implemented in September and October 2003 and had a particular emphasis on the provinces Punjab and Sindh. The authors are very grateful to all the individuals listed below and appreciate their help and the time they had shared with Dr. Yameen Mohammad Memon and Dr. Bakhshal Lashari making the field program a success.

Date	***Name***	***Designation***	***Organization***	***Place***
12/9/2002	Mr. Faqir Muhammad Jumani	Director	SMO,WAPDA	Hyderabad
	Mr. Ghulam Kadir Bhutto	Team Leader	Pakistan Drainage Consultants (PDC) Sindh	Hyderabad
	Mr. M. Ramzan Palh	Drainage Engineer	Pakistan Drainage Consultants (PDC) Sindh	Hyderabad
13/9/2002	Rao Abdul Jabbar	Director General	OFWM, Sindh Agriculture Department	Hyderabad
	Mr. Mumtaz Ali Memon	Managing Director	Sindh Irrigation & Drainage Authority (SIDA)	Hyderabad
	Mr. Bashir Dahar	Chief Engineer	Irrigation (Development)	Hyderabad
	Mr. Madhudas	Retired Chief Engineer	Irrigation & Consultant ACE	Hyderabad
14/9/2002	Mr. Raghib Abbas Shah	Chief Engineer	WAPDA South	Hyderabad
	Mr. Jelle Beekma	Irrigation & Drainage Advisor	Institutional Reforms Consultants (IRC) SIDA	Hyderabad
15/9/2002	Mr. Mushtaq Mirani	Executive Trustee	Sindh Rural Support Program (SRSP)—NGO	Hyderabad
	Mr. Allah Warayo Channa	Consultant and Rtd. Chief Engineer	Right Bank Outfall Drainage Project	Karachi
16/9/2002	Mr. A. N. G. Abbasi	Rtd. Engineer	Irrigation Department	Karachi
	Ms. Simi Kamal	Chief Executive	RAASTA Development	Karachi
	Mr. F. H. Mughal	Director	Sindh Environmental Protection Agency, Government of Sindh	Karachi
	Mr.Mohmamad Hashim Leghari	Secretary	Irrigation and Power Department, Government of Sindh	Karachi
17/9/2002	Mr. Khadim Ali Memon	Additional Secretary	Irrigation and Power Department, Government of Sindh	Karachi
	Brig. Abdul Haque	Provincial Coordinator	National Drainage Program Sindh	Karachi
18/9/2002	Mr. Usman Qamar	Task Manager	World Bank	Islamabad
	Dr. Shahid Ahmed	Senior Director (Water)	National Agricultural Research Council (NARC)	Islamabad
	Syed Abid Shah	Senior Environmental Advisor	Hagler Bailly Pakistan	Islamabad

Date	***Name***	***Designation***	***Organization***	***Place***
19/9/2002	Mr. Riaz Ahmed Khan	Chief Engineering Advisor	Federal Flood Commission, Government of Pakistan	Islamabad
	Dr. M. Ashraf	Director	PCRWR	Islamabad
	Mr. Zia-ul-Islam	Director	Pakistan Environmental Protection Agency, Government of Pakistan	Islamabad
	Mr. Tila Mohmmad	Deputy Chief Planning	Planning Dept., Government of Pakistan	Islamabad
	Dr. Kausar Abdullah	Director	Pakistan Atomic Energy Center	Islamabad
20/9/2002	Ch. Muhammad Anwar	Superintending Engineer	Drainage Circle, Faisalabad (Irrigation)	Faisalabad
	Mr. Abdul Hameed	Team Leader	IWMI, Pakistan	Faisalabad
21/9/2002	Mian Abdul Wahid	Chairman	Farmer organization , Hakra 4-R	Haroonabad
	Haji Muhammad Amin	Secretary	Farmer organization , Hakra 4-R	Haroonabad
	Abdul Jameel Khan	Secretary	DBG (Chak No. 85/5R)	FESS Area Haroonabad
	Raja Amjad	Chairman	DBG (Chak No. 149/6R)	Haroonabad
22/9/2002	Mr. Mike Percy	Team Leader	Pakistan Drainage Consultants, Pakistan	Lahore
	Dr. M. Shafique Siddiq	Team Leader	UNOPS - NDP	Lahore
	Ms. Zaigam Habib	Ex-Irrigation Specialist	IWMI, Pakistan	Lahore
23/9/2002	Mr. Sabir Ali Bhatti	Water Resource Development Specialist	Sector Policy Studies Project - NDFP - ACE (PVT) Ltd.	Lahore
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	Mr. Altaf Iqbal	Group Leader/ Economist	Sector Policy Studies Project - NDFP - ACE (PVT) Ltd.	Lahore
	Mr. Zuberi	Advisor	Research Advisory Committee, NDP	Lahore
	Mr. Shafiq ur Rehman	Director	National Drainage Program, WAPDA	Lahore
	Mr. Javed Majid	Secretary	Government of Punjab, Irrigation Department	Lahore
	Mr. Zafar Iqbal Mirza	Executive District Officer	Government of Punjab, Agriculture	Lahore
24/9/2002	Mr. Asrar-ul-Haq	Additional Secretary (Technical)	Government of Punjab, Irrigation Department	Lahore
	Dr. Nawaz Bhutta	Director General	IWASRI	Lahore
	Dr. Muhammad Ramzan Chaudhry	Director	IWASRI	Lahore
	Dr. L. A. Hijazi	National Project Manager	UNDP, IWASRI	Lahore

Date	Name	Designation	Organization	Place
	Ch. Karamat Ali	Director	Land Reclamation, Government of Punjab, Irrigation Department	Lahore
	Dr.Ashraf A Bodla	Environmentalist	NDP	Lahore
	Mr. Mushtaq Ahmed Gill	Director General	OFWM, Punjab Agriculture Department	Lahore
	Dr. Ashraf	Director	OFWM, Punjab Agriculture Department	Lahore
25/9/2002	Mr. Shahid Siddiq Goheer	Field Coordinator	PPSGDP	Lahore
	Mr. Ch. Nazar Akhtar	Project Manager	PPSGDP	Lahore
	Mr. M. Iqbal Chaudhry	Sr. Sociologist/ Team Leader	ESD Division, MM Pakistan(Pvt) Ltd.	Lahore
	Mr. Ahmed Khan Bhatti	Member Water	WAPDA	Lahore
	Mr. Ch. Rafique Ahmed	Superintending Engineer	SCARP	Lahore
	Mr. Shabir Ahmed	Farmer/ Secretary	DBG - CTW, Tiba Kazi Kaiser Town	Lahore
26/9/2002	Mr. Aslam Qureshi	Provincial Coordinator	NDP Punjab	Lahore
	Mr. Muhammad Siddique	Chairman	DBG, Surface Drainage Project OFWM	Lahore
27/9/2002	Dr. Muhammad Abid Bodla	Member Engineering	Planning & Development Board, Government of Punjab	Lahore
	Mr. Muhammad Hussain Goraya	Chief Eningeer/General Manager	NDP/ Provincial Coordinator	Lahore
	Eng. Aijaz Ahmed Pitafi	Deputy Director	National Drainage Program	Lahore
	Dr. Asad Qureshi	Acting Director	IWMI, Pakistan	Lahore
	Dr. Waqar Jehangir	Agricultural Economist	IWMI, Pakistan	Lahore
	Mr. Shafqat Masood	General Manager	Punjab Irrigation & Drainage Authority (IDA)	Lahore
28/9/2002	Mr. Iqbal Sandhu	Resident Engineer	Second Flood Protection Project, Engineering Consultants International	Karachi
	Mr. Muhammad Ali Shaikh	Director	Center for Research & Information, SZABIST,	Karachi
1/10/2002	Mr. Noor Ahmed Shaikh	Project Director	SCARP Sindh Project	Naushero Feroz
	Mr. Suleman Abro	Chief Executive	Sindh Agricultural & Forestory Workers Coordinating Organization	Shahdadpur, Sanghar
2/10/2002	Mr. Fazal Muhammad Kolachi	Project Director	SCARP	Sukkur
3/10/2002	Mr. Saeed Ahmed Chaudhry	Manager/Progressive Farmer	Nawaz Abad Farm	Mirpurkhas

Date	***Name***	***Designation***	***Organization***	***Place***
	Mr. Arif Iqbal	Secretary	Farmer organization, Bareji Distributary	Mirpurkhas
	Mr. Agha Aijaz	Director	Nara Canal Area Water Board	Mirpurkhas
	Syed Ali Gohar Shah	Chairman	Farmer organizations Council	Mirpurkhas
	Mr. Sarfraz Junejo	Chairman	Farmer organization Kahu Minor	Mirpurkhas
	Mr. Yar Mohd Baloch	Chairman	Farmer organization Bareji Distributary	Mirpurkhas
	Mr. Maqbool Ahmed	Chairman	Farmer organization Potho Minor	Digri
4/10/2002	Mr. Mustafa Abro	Economic Advisor to Vice Chancellor	University of Sindh	Jamshoro
	Dr. Pervez Pathan	Economist	Sindh Development Studies Center, University of Sindh	Jamshoro
5/10/2002	Mr. George Hartman	Team Leader	Institutional Reforms Consultants, SIDA	Hyderabad
	Mr. Egbert Hamel	Irrigation & Drainage Advisor	Institutional Reforms Consultants, SIDA	Hyderabad
	Syed Mazhar Hussain Shah	Superintending Engineer	Left Bank Drainage Circle, Irrigation Department, Government of Sindh	Hyderabad
6/10/2002	Mr. Sharif Bughio Mr. Bagh Ali Arain	Farmer/Member	Community Tubewell Group	Sakrand

Additional interviews

- Water User Federation Innuana Distributary, Shahkot district Faisalabad
- Drainage beneficiary group pilot site at Yarwah Minor, Bahawalnagar (IWASRI)
- Drainage Beneficiary Group Khanna Lubhana, Muridke, Sheikupura district
- Drainage Beneficiary Group Village 64/RB, Shahkot, Faisalabad district
- Drainage Beneficiary Group Walianwala, Gujranwala district
- Community Tubewell Groups Sharaqpur, Qila Lal Singh and Ferozewala

Appendix B. Drainage Infrastructure in Pakistan

Open drainage infrastructure

In the flat Indus plains, open drainage infrastructure consists of natural and artificial components. High intensity rainfall flows toward depressions to natural Nallahs which carry the water to rivers and depressions. Nallahs are permanent watercourses that receive water flows from the lands and, in some locations, wastewater from settlements and industry. Manmade drains were constructed to dispose seepage as well as stormwater. In few locations, the artificial drainage infrastructure comprises tertiary open drains that connect the fields to tributary and main drains.

More recently, Nallahs and artificial drains also serve as dumps for industrial and communal effluents. Since these drainage waters are composed of sewerage, untreated industrial effluents and saline groundwater, and are generally lifted back into canals and recycled within the irrigation system, they have increased health hazards, soil salinization and sodification.

Seepage drains

Seepage drains are built where agricultural lands are waterlogged to take away the subsoil water from below the root zone for proper growth of crops. The drains carry saline and otherwise polluted water to big canals, rivers etc. Outfall main branch, tributary and subtributary drains are constructed for receiving and transporting surface and subsurfacewater to an outfall (e.g. depressions, evaporation ponds, lakes, the sea).

Tile drainage

Tile drainage systems remove the water that has entered the soil profile. Buried tile drains are placed beneath the soil surface to take out excess water only. A scheme size of 40.5 to 60.7 ha is regarded to be the economic minimum; it could drain the land of only one farm, but the general pattern is that laterals and collectors serve many farms.

Laterals—buried drainage pipes—collect soil water continuously over its full length through gates at the pipe joints or perforations or slots in the pipe wall. They are corrugated PVC plastic pipes which are installed below the land surface. The laterals are generally laid at a slope of 0.3 m per 328 m with a velocity of 0.3 m/sec. Collectors, again buried pipes, collect soil water from a series of laterals on either sides and convey the combined flow to the outlet point in small schemes; in larger schemes several collector drains are connected to main drains. In addition, the collector pipes may have gaps or slots to act as a direct receiver of the soil water throughout its length. As more laterals continue to join the collectors, their size increases to carry the increasing seeping water. The collectors are laid at a slope of 0.3 m per 656 m, and the minimum velocity is 0.3 m/sec. The length of laterals and their distance is worked out based on the discharge expected at the site depending on the permeability of the area, the depth of the drain, the groundwater and the distance apart of the laterals. A main drain - a main pipe - collects soil water from the collectors and conveys the combined flow to the outfall. The main pipe may have gates or slots to act as a direct receiver of soil water throughout its length. At manholes laterals and collectors join; they serve as junction boxes, silt and sand trap, observation wells, discharge measurement facilities and entrance to the drains for maintenance. Manholes help in identifying problems in drain lines, if any. In some instances the water level in outlet ditches is higher than the water level in the collector or the main ditch at the outlet point. In these cases, sumps (i.e. tanks) are installed including a pump for transferring the drained water from the sump into the higher outlet (i.e. natural drain or open ditch). A sump is constructed by a pit at the lowest point in the field near the outlet drain. Outlets are the terminal point beyond which the water collected can no longer be controlled. It is the most important part of the system, and the selection of its site requires careful consideration. Excess water can be disposed off by means of gravity or pumping, or both, into natural streams and natural depressions.

Tubewells

Deep and shallow tubewells are installed in fresh groundwater areas, deep tubewells in saline groundwater areas only to provide vertical drainage for combating waterlogging. In addition to their drainage objective, tubewells in fresh groundwater areas exploit fresh groundwater to increase irrigation water availability. In general, shallow tubewells are installed to fetch water up to 2 cusecs, whereas deep wells could be fetching water up to 5 cusecs. The freshwater tubewells are usually installed near to watercourses so that water can be directly released into the watercourses. Saline groundwater from saline tubewells is drained into small and main drains through disposal channels. The life span of tubewells is at least around 20 years if properly operated and maintained. Both electric motors and diesel engines are used for operation.

Appendix C. Background Material

Table C1 Number and size of farms (1990)

Province	*Number of farms*	*Farm size (ha)*	*Average size (ha)*
Punjab			
All farms	2,957,462	11,009,671	—
Government farms	72	39,482	—
Private farms	2,957,390	10,970,189	3.7
<0.5	363,471	104,576	0.3
0.5 to 1.0	385,221	286,052	0.7
1.0 to 2.0	593,996	827,134	1.4
2.0 to 3.0	499,571	1,181,308	2.4
3.0 to 5.0	506,270	1,964,752	3.9
5.0 to 10.0	406,177	2,633,630	6.5
10.0 to 20.0	147,388	1,845,592	12.5
20.0 to 60.0	48,566	1,377,947	28.4
>60.0	6,730	749,198	111.3
Sindh			
All farms	801,979	3493,054	—
Government farms	16	11,089	—
Private farms	801,963	3,481,965	4.3
< 0.5	2,712	10,352	0.4
0.5 to 1.0	69,458	54,580	0.8
1.0 to 2.0	168,208	245,855	1.5
2.0 to 3.0	178,290	415,368	2.3
3.0 to 5.0	197,353	753,487	3.8
5.0 to 10.0	108,468	752,765	6.9
10.0 to 20.0	33,769	443,926	13.1
20.0 to 60.0	14,612	426,704	29.2
>60.0	3,093	378,928	122.5

— Not available. Source: Govt. of Pakistan, Ministry of Food, Agriculture and Livestock Economic Wing (1998-99): 114.

Box C1 Laws and regulations

Federal Laws

- Water and Power Development Authority (WAPDA) Act, 1958
- Indus River System Authority (IRSA) Act, 1992
- Pakistan Environmental Protection Act, 1997

Provincial Laws

- The Canal and Drainage Act, 1873
- (Punjab Amendment Act 1952. Extension Act 1964.
- West Pakistan Amendment Act 1956, 1968, and Ordinances of 1970.
- Punjab Amendment Ordinance 1971 and Amendment Act 1975)
- The Sindh Irrigation Act, 1879
- The Punjab Minor Canal Act, 1905
- The NWFP Amendment Act, 1948
- Punjab Soil Reclamation Act, 1952
- West Pakistan Amendment Ordinance V of 1964
- West Pakistan Land and Water Development Board (Control over Underground Waters) Rules, 1965
- Soil Reclamation (Punjab Amendment) Ordinance VI of 1970
- Punjab Soil Reclamation (Amendment) Act. IX of 1977
- Baluchistan Canal and Drainage Act, 1980
- Punjab Water User's Association Ordinance, 1981
- NWFP Water User's Association Ordinance, 1981
- Baluchistan Water User's Association Ordinance, 1981
- Sindh Water User's Association Ordinance, 1981
- Water Apportionment Accord 1991

Recently Enacted Laws

- Punjab Irrigation and Drainage Authority Act, 1997
- Sindh Irrigation and Drainage Authority Act, 1997
- Sindh Water Management Ordinance, 2002
- Buluchistan Irrigation and Drainage Authority Act, 1997

Table C2 Classification of irrigation water quality

Property	***Good***	***Marginal***	***Hazardous***
Electrical conductivity (EC)	<0.75	0.75–2.0	>2.0
Sodium absorption ratio (SAR)	<5.0	5.0–10.0	>10.0
Residual sodium carbonate content (RSC)	<1.25	1.25–2.5	>2.5

Source: Pakistan Drainage Consultants (2000): 5.

Table C3 Salinity Control and Reclamation projects

S#	*Project*	*Period of construction*	*Cultivable area (million ha)*	*Tubewells (number)*	
				SGW	*FGW*
Punjab provinice					
1	SCARP-I	1960–63	0.462	—	2,069
2	SCARP-II (FGW)	1961–83	0.603	—	2,205
3	SCARP-II (SGW)	1961–83	0.223	821	—
4	SCARP-III (FGW)	1969–81	0.385	—	1,635
5	SCARP-III (SGW)	1969–81	0.039	61	—
6	SCARP-I Muridki	1969–73	0.220	—	935
7	SATINA	1975–77	0.039	51	20
8	Shorekot Kamalia	1975–77	0.062	—	101
9	Allabad	1975–79	0.082	—	623
10	Minchinabad	1976–80	0.030	23	203
11	Shahpur	1975–79	0.045	—	258
	Total		2.181	956	8,049
Northwest Frontier province					
1	Peshawar	1972–82	0.048	—	218
2	Bannu	1976–82	—	—	176
3	Y.W. Sharif	1979–80	—	—	97
4	Khanwand	—		—	—
	Total		0.048	—	491
Sindh province					
1	Khanpur	1963–70	0.154	365	175
2	N. Rohri	1969–79	0.278	—	1,192
3	Shikarpur	1973–74	0.006	—	50
4	Larkana	1974–75	0.002	—	35
5	Sukkur	1977–78	0.002	—	18
6	Kandhkot	1977–78	0.005	—	26
7	Sukkur R.B.	1975–79	0.053	—	400
8	Ghotki	1976–90	0.162	—	1,050
9	South Rohri	1976–89	0.152	—	1,215
	Total		0.812	365	4,161

Source: Ahmad (1998): 5-B-10–12.

Table C4 Drainage beneficiary groups on tertiary open drains

Name/location in Punjab	***Catchment area (ha)***	***Members (number)***	***Drainage required***	***Technical means***	***Farmer contributions toward investments***	***Public share (Rs.million)***	***State agency***	***Funds***
"Walianwali" , Gujranwala District	1,446.60	207	Ponds flooded by heavy rains	1 surface drain (10 km, 90 cusecs); 1 outfall; 36 inlets	Land	3.6	OFWM	OECF
"Ramke Sindhwan", Gujranwala District	422.7	77	Ponds flooded by heavy rains	1 surface drain (2.5 km); 1 out fall; 13 inlets	Land	0.7	OFWM	OECF
10 DBGs in Dera Ghazi Khan, Muzaffargarh District	1,500.4 (gross) 1,240.5 (net)	481	Waterlogging and salinity due to heavy rains and excess irrigation	10 surface drains (19.8 km); watercourse escape	Land (from 179 beneficiaries)	3	OFWM	ADB
"Village No.64"	263.6	164	Ponds flooded by heavy rains; water table 0.91 to 1.22 m.	2 surface drains (0.86 km, 0.9 km); 3 out falls	Registration of DBG Scheme agreement Land 10 percent of initial costs Up-front payment Spreading of excavated material Excavating field drains Free/unrestricted access to site	—[b]	OFWM	NDP
Rukh Branch Canal, Faisalabad District								
"Khanna Lubhana"[a] Ferozewala Tehsil	375.3	98	Ponds due to heavy rains	1 surface drain; locking device	Land donation Rs. 247/ha	0.9	OFWM	OECF

Table C4 Drainage beneficiary groups on tertiary open drains

Name/location in Punjab	*Catchment area (ha)*	*Members (number)*	*Drainage required*	*Technical means*	*Farmer contributions toward investments*	*Public share (Rs.million)*	*State agency*	*Funds*
11 villages in Drainage IV project area	10,526.30		Waterlogged with water table depth 0 to 1.52 m.	Surface drains	Registration of DBG Scheme agreement Land Ten percent of initial costs Up-front payment No compensation for crop damages Spreading of material Providing skilled and unskilled labor	Rs. 100 to 200 per acre	WAPDA	NDP
Innuana Distributary WUF Nankana Sahib Tehsil	Fields of one-fourth of 1,415 farmers	WUA members	Water stored in watercourse floods low lying field; seepage from watercourse	Watercourse escape (7 km) to main drain	Labor		OFWM	n.a.

n.a. Not applicable.

a. Part of OFWM -III Project (1997-98) with 25 DBGs (16,194 ha and 3,060 beneficiaries). b. Ninety percent of costs.

Source: Authors' compilation (1999; 2000).

Table C5 Drainage beneficiary groups on tile drainage schemes

Location	*Most affected area/farmers*	*Drainage objectives*	*Technical means*	*Farmers contributions*	*State or/a. donors*
Fordwah Eastern Sadiqia (IWASRI)[a]	133.6 ha 40 farmers	Waterlogged fields	Tile-cum-sump	O&M costs except fuel	Initial costs
FESS, Hakra Distributary, Hakra and Malik Branch[b]	237.2 ha	Waterlogged and saline land due to seepage from branch and distributary	18 units of interceptor-cum-subsurface drainage along 83 km irrigation canals	Labor for O&M Formation of DBGs	Initial costs
Drainage IV project, Phase-I Faisalabad district[c]		Waterlogged fields	79 units comprising 540m tile drains 197m surface drains	Land	Initial costs Compensation for land losses and crop damages
Drainage IV project, Phase-II, Faisalabad district[d]	5,430 ha 3,260 farmers 47,601 residents	Waterlogged fields	65 units comprising tile-cum-sumps surface drains	DBG registration 10 percent up front contributions of civil works costs Land for sumps, manholes and disposal channels	Construction costs of tile drains

a. Completed and transferred; b. Planning stage; c. Completed, transfer intended; d. Planning stage.

Source: Authors' compilation (1999; 2000).