DRAFT FIELD REPORT

FAISALABAD, PAKISTAN

CASE STUDIES IN THE ENVIRONMENTAL SUSTAINABILITY OF WATER RESOURCE MANAGEMENT

Prepared for the

Irrigation Support Project for Asia and the Near East

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&

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PREFACE

It was a unique privilege to participate in this project in which we dedicat d our energies and experience to an examination of the history and future of water management in Faisalabad District of Pakistan. We seldom have the luxury to focus all our efforts on the examination of such a profound and important issue at the heart of our future. We are grateful for the opportunity and for the assistance and insights received from all who participated. The people of Pakistan are highly conscious of the importance of sustainable development of the their resources, especially water. This high degree of awareness was evident in all our discussions with scientific and government people, especially those beginning the work of the environmental sector.

The strongest evidence of environmental concern in Pakistan is found in the National Conservation Strategy, published in 1991, and the Pakistan National Report to the UN meeting in Rio de Janeiro of 1992. These two documents, and their authors, provided the foundation upon which this report was established. There is no lack of knowledge or concern in Pakistan. The task in the future is to harness this in an effective and sustainable strategy.

It is also fitting to note the love of people in Pakistan for green spaces and gardens. In the three cities we visited, Islamabad, Lahore and Faisalabad, the first order of the day for many people was a stroll in the gardens or green spaces of their communities. Women, children and men, in families, groups or alone, rose at dawn and sought refreshment and communion with the trees, water, people, birds, and Ibex who inhabited these green spaces. For the urban dwellers of Islamabad, Faisalabad and Lahore, these dawn and dusk forays are probably a way of recreating the daily experience of their farmer ancestor who rises from his bed under a great mango or neem tree, awakened by birdsong and the stirring of farm animals. Preservation of this rural custom by dwellers in the most crowded, noisy and contaminated communities, offers a vision of a livable future in Pakistan, if we find the way, in time.

We are extremely grateful to our colleagues in this study, including personnel of USAID, the World Bank and UN agencies, WAPDA, the Punjab Environmental Protection Agency, Punjab Irrigation Department and the Ministry of Health, as well as the professional members of Faisalabad government agencies. The ISPAN personnel are especially grateful for the technical support of staff members of EDC, and also for their lively discussions and intellectual stimulation. Their warm hospitality, like that of all the Pakistani people we encountered, will long be remembered.

SUMMARY

An analysis was made of recent and future trends in competition for water by the urban and rural sectors in Faisalabad District of Punjab Province, Pakistan. It was determined that competing demands for water could have been satisfied in a more sustainable manner by following a few principles basic to environmental sustainability.

General recommendations were made so that similar communities in Pakistan and nearby countries could benefit from the case study of Faisalabad. These recommendations should be of interest not only to those communities but also to donor agencies supporting water resource management projects in Pakistan, including USAID.

The total population in Faisalabad District in 1990 was 5 million, with a projected population for the year 2020 of 3 million. In the urban Faisalabad the population is expected to reach 4 million by 2020. Although the population will more than double in this period, the water supply will increase by only 5-10% due to groundwater extraction, thus competition for water will intensify severely.

Status of the Resource

Quantity

The quantity of water available for urban and rural use was obtained at the turn of the century by the construction of the Lower Chenab Canal which took water from the Chenab River about 100 kilometers North East of Faisalabad and delivered it by gravity canals. The three branch canals serving the District from this system are the Jhang, Ravi and Gugera Canals. They are presently delivering 5,500 million cubic meters per year at the District boundary, and this flow cannot be increased.

The amount of water coming into the District has not increased over the years, and because of roughly 35% irrigation efficiency in the rural portions of the District, only about 2,200 million cubic meters are applied to the crops each year at present.

Because the supply for the entire District has not increased but the human population, including urban and rural areas, has grown from 2.5 million in 1950 to 5 million in 1990, the available water per capita in the District has dropped from 2,200 cubic meters per year to 1,100 CM/yr/person in 1990. Projections for 2020 are that it will drop to 800 CM/yr/person due to increased population alone.

The rapid decrease experienced in the quantity of water available per person causes considerable concern for the future of food production which was already below desirable levels. A malnutrition survey of 1975 showed that half of the children in Pakistan were clearly malnourished, and without parallel increases in food production, there would be a severe drop in per capita food supply and nutrition by 2020. The possible 27% drop in per capita water availability for food crops projected for 2020 could easily result in famine.

As the urban portion of Faisalabad District grew, due to normal increases and due to industrialization after 1960, the city increased its demand for water markedly. The amount originally supplied from the Rakh canal no longer met the urban population's needs, and severe shortages developed by 1980. The urban population rose from 0.5 million in 1950 to 1 million by 1980 and 1.5 million by 1990. It is projected to reach 4 million by 2020.

The annual supply of domestic water available for urban use was 150 million cubic meters in 1993. Only 30 million cubic meters of this total were taken from the canals, from the Rakh Branch. The rest was pumped from tubewells in the urban area, and from a new wellfield near the Chenab River 30 kilometers North East of the urban area.

As the urban population increased, their water consumption also increased, from 17 MCM annually in 1950 to 150 MCM by 1993. Projections for 2020, including industrial needs, are about 350 MCM annually, neglecting industrial expansion. With significant industrial expansion, the urban demand could reach 500 MCM easily. Only 300 MCM are available, thus the urban sector would have to draw on supplies presently going to the rural sector. In 1950 about 0.5% of the irrigation flow was needed for urban use, but by 2020 as much as 5% might be needed. This need will clearly be in conflict with the rural demand for more food production.

Quality

In terms of conflict between the urban and rural sectors, there have not been severe problems of water quality to the present time, although within these sectors there have been very important problems of salinity and fecal contamination of drinking water.

The main conflict between the urban and rural sectors will occur in the near future, and will be due to industrial and agricultural contamination in the aquifers used for domestic drinking water.

In urban Faisalabad there was a surge in textile and food

industries starting about 1960. By 1990 there were over 300 individual industries discharging untreated wastewater to natural depressions and water channels leading to the Chenab and Ravi Rivers. This wastewater contained large amounts of organic material which killed most aquatic life in the streams and rivers immediately below the discharges. In addition many of them contained toxic metals and probably industrial solvents which will penetrate the aquifers below the Ravi and Chenab Rivers. The Ravi river aquifer is probably already contaminated by industrial discharges from Lahore.

Actions to Reduce Degradation of the Resource

Quantity

In the rural sector, the increased demand for water to produce more food was met by the agricultural improvements of the Green Revolution, and by programs called SCARP, aimed at reclaiming waterlogged land through the use of deep tubewells. Command Water Projects and On Farm Water Management Projects were developed to increase available water by lining farm ditches called watercourses, and thus increase irrigation efficiency. The Fourth Drainage project was created to increase the supply of water by re-using drainage water collected from subsurface drains. Shallow tubewells were installed by some villages to improve their water sources.

In the urban sector the increased demand for domestic and industrial uses was met by placing deep wells in the aquifer on the East Bank of the Chenab River to draw water for the Corporation's needs. This was completed in 1992 and the next step will be to draw additional water from Rakh Canal. To meet the urban water demands of 2020 it is expected to develop more deep wells in the Chenab River aquifer.

Quality

The first approach to dealing with the rapidly growing amounts of industrial and domestic wastewater being discharged to the natural drainage system was to construct large sewers to lead this wastewater to treatment plants. Although the plan is for separate industrial and domestic treatment plants, the waste flows will be combined because the industries are scattered throughout the city. Furthermore the sewers will mix rain water with the domestic and industrial sewage.

Possible Alternative Approaches

The attempts to increase the quantity and quality of water available could have been made more sustainable by four

INTRODUCTION

This report is part of a regional study on the environmental sustainablility of water resource management supported by the Irrigation Support Project for Asia and the Near East (ISPAN). ISPAN is a water resources and water policy project sponsored by the Asia and Near East Bureaus of the U.S. Agency for International Development. The objective of the study is to examine the evolution of competing demands for water resources between urban/industrial and rural/agricultural sectors -- particularly with reference to food security, energy and potable water -- in Pakistan, Egypt, Morocco and Thailand. The purpose of the study is to determine the social, economic, institutional and technical requirements for the countries under study to strengthen their water resources management capacity, and to develop or improve environmentally sustainable strategies for water resource conservation and management. The results of the study will be of direct use to AID and other donor agencies and host country governments in their efforts to promote environmentally sound development strategies in the decades to come.

Environmental Sustainability: An Operational Definition

The study has adopted an operational definition of environmentally sustainable management of water resources based on the broader concept of sustainable development put forth in the report of the World Commission on Environment and Development (commonly known as the "Bruntland Report"):

> Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

The application of this concept to water resource development and management requires planners and policy makers to focus on the ecological, social and institutional dimensions of water use. This focus is fully consistent with AID's strategic objectives for water resource development, namely:

- to increase the efficient use of water by promoting water conservation in all sectors to reduce consumption;
- to enhance water quality by encouraging pollution prevention and monitoring to increase and protect usable water supplies; and
- to improve water management by fostering private sector

solutions, by increasing government accountability and by promoting local empowerment in the management of water resources (AID 1993:v)

This study aims to draw on lesson's learned from the Pakistan case to recommend strategies for the achievement of AID's water resource development objectives that are relevant not only to Pakistan, but to countries and AID programs throughout the region.

Study Framework

This study was conceived by the AID Asia and Near East Bureaus and the ISPAN staff to link the regional water resource development strategies with AID's evolving environmental and sustainable development objectives. Since the beginning of the decade, AID has supported the development of environmental research and information dissemination through a series of centrally-funded projects. In addition, AID has begun to address the environmental crises arising from growing urbanization and industrialization in a number of developing countries through its support of specific urban waste management and industrial pollution prevention projects.[1]

ISPAN convened a team in December 1992 to begin formulating a study to address the environmental implications of AID's water resource development and management activities. In consultation with project officers of the AID Asia and Near East Bureaus, the team members developed a paper that reviewed the concepts of environmental sustainability and applied these concepts to water resource management. This concept paper was subsequently disseminated to participating Missions (Pakistan, Egypt, Morocco and Thailand) for review. Study team members followed up on the delivery of the concept paper with reconnaissance visits to each of the Missions in order to review the Mission's water project portfolios and determine appropriate projects for consideration. Following on these reconnaissance missions, the team chose to narrow the study focus to the competition for water resources between urban/industrial and rural/agricultural sectors in order to highlight what it considered to be the most critical environmental issues related to water resource development and management.

With the approval of the Missions and the AID Bureaus, the study team scheduled field visits to each participating country.

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[1] Among the projects cited are: the Environmental Policy and Training Project (EPAT); GREENCOM; Environmental Pollution Prevention Project (EP3); Project in Development and Environment (PRIDE); the Privatization of Urban Services Project (PURSE/Indonesia); and Industrial Environment Management Project (IEMP/Philippines).

The team, working with local consultants, will prepare draft case studies for each country and leave copies of the case study for review by Mission personnel. On completion of each case study and receipt of comments by each Mission and the AID Bureaus, the team will prepare a synthesis report of lessons learned from all case studies.

Methodology and Personnel

The three week time allotted for each country study precluded extensive data collection in the field. After careful consideration of data collection and field logistics constraints in Pakistan, the team selected Faisalabad as the most suitable area for its case study.

The team made extensive use of secondary data and rapid appraisal methods to construct the chain of events linking development interventions with observed impacts, to analyze major development issues, and to identify key lessons learned. The team employed several sources of information and appraisal techniques, including:

- **USAID Project Documents** -- Project papers, technical reports and evaluations of the major USAID-funded water resource projects of the last two decades such as On Farm Water Management, Irrigation Systems Management I & II and Command Water Management;

- **Other International and National Agencies** -- Project design, technical reports, progress reports and evaluations generated by other foreign assistance donors (the World Bank, UNDP, the Asian Development Bank, IUCN, Pakistan's Environment and Urban Affairs Department, WAPDA and the Punjab Environmental Protection Agency);

- **Key Informant Interviews** -- USAID project officers; officials of other donor agencies; officials of government line agencies at the national, provincial, district and municipal levels; knowledgeable environmental and related technical specialists; industry managers; and farmers.

- **Field Visits** -- Visits USAID and other donor agency project sites, irrigation and drainage works, water and sewage treatment facilities, farms and factories in the Faisalabad area.

A complete list of documents and reports cited for this study can be found in the References section. A list of all individuals consulted and the itinerary of the study team is attached as Annex B.

The ISPAN Study team was represented by Dr. William Jobin, Public Health Engineer and Dr. Richard English, Anthropologist & Institutional Development Specialist. The study team was ably supported by a team of consultants working with Enterprise and Development Consulting (Pvt.) Ltd. of Islamabad including: Dr. Nasir-ud-Din, Water Resources Specialist; Dr. Tariq Husain, Resource Economist; Mr. Syed Ayub Qutub, Environmental Specialist; and Mr. Najib Murtaza, Industrial & Toxic Waste Specialist.

Report Format

The report begins with a brief review of water resource issues related to urban and industrial growth in the developing world. This review is followed by a profile of Pakistan's water resources, and the environmental implications of the country's management of those resources. This background section concludes with a profile of Faisalabad, and a justification for the selection of Faisalabad as a case study for environmentally sustainable water resource management in Pakistan..

The body of the report falls in three chapters: Water Quantity Issues; Water Quality Issues; and Related Environmental Issues (e.g., public health, biodiversity and climax phenomena such as flooding). Each of these chapters follows a general format that examines: 1) the rationale and impact of historical water management actions; 2) the nature and effectiveness of development interventions made to remedy the negative impacts of historical water management actions; and 3) based on current knowledge, what would have been more effective approaches to the management of water resources. Within each chapter, the report considers the issues in terms of the technological, institutional, policy, economic and social (i.e., equity) concerns. The report concludes with a discussion~~s~~ of lessons learned from the review of the Pakistan experience and the implications of those lessons for broader environmentally sustainable water resource management policy in developing countries.

1. BACKGROUND

This chapter reviews the overall theme of the study -- the urban and rural competition for water resources -- within the context of the developing world and, from a more detailed perspective, within the context of Pakistan as a whole. The chapter goes on to describe the way in which this competition for water resources has developed in Punjab's Faisalabad District, and justifies the selection of Faisalabad as a case material for the study

The Competition for Water Resources: Urban vs. Rural

Agriculture remains the principal economic sector of the majority of developing nations. However, the late twentieth century is witnessing inexorable growth of population, urbanization and industrialization throughout the developing world. Development indicators suggest that the advances made in food production during the "Green Revolution" are not sustainable in the face of current trends in population growth despite donor and host government attempts to make improved technology and inputs widely available.

For most developing countries, agriculture outpaces all other sectors in its demand for water by a factor of five (see Table 1.1). However, there are clear signals that, as competition for water grows between the agricultural, municipal and industrial sectors, donors and host governments alike must support more comprehensive water management policy and practice to conserve the water resources. Many governments for which the cost of bringing new lands under cultivation is prohibitive are facing the need to balance the cost of maintaining adequate water supplies for agriculture with the costs of promoting industrial development and providing environmental infrastructure (water supply, sewerage and drainage) to their urban populations. Against this background of urban vs. rural competition for what were once considered unlimited resources, this report examines the development of water resource management in Pakistan. The report attempts to draw from very specific social, economic, technological and institutional developments some general principals that apply to the planning of environmentally sustainable water resource management in the 21st Century.

Table 1.1
Water Use By Sector in Near Eastern Countries with Comparison to Pakistan

	Agriculture	Industry	Municipal & Domestic
Egypt	88%	5%	7%
Israel	79%	5%	16%
Jordan	71%	5%	24%
Lebanon	84%	4%	11%
Morocco	91%	3%	6%
Oman	94%	3%	3%
Tunisia	80%	7%	13%
Yemen	93%	2%	5%
Pakistan	**95%**	**2%**	**3%**

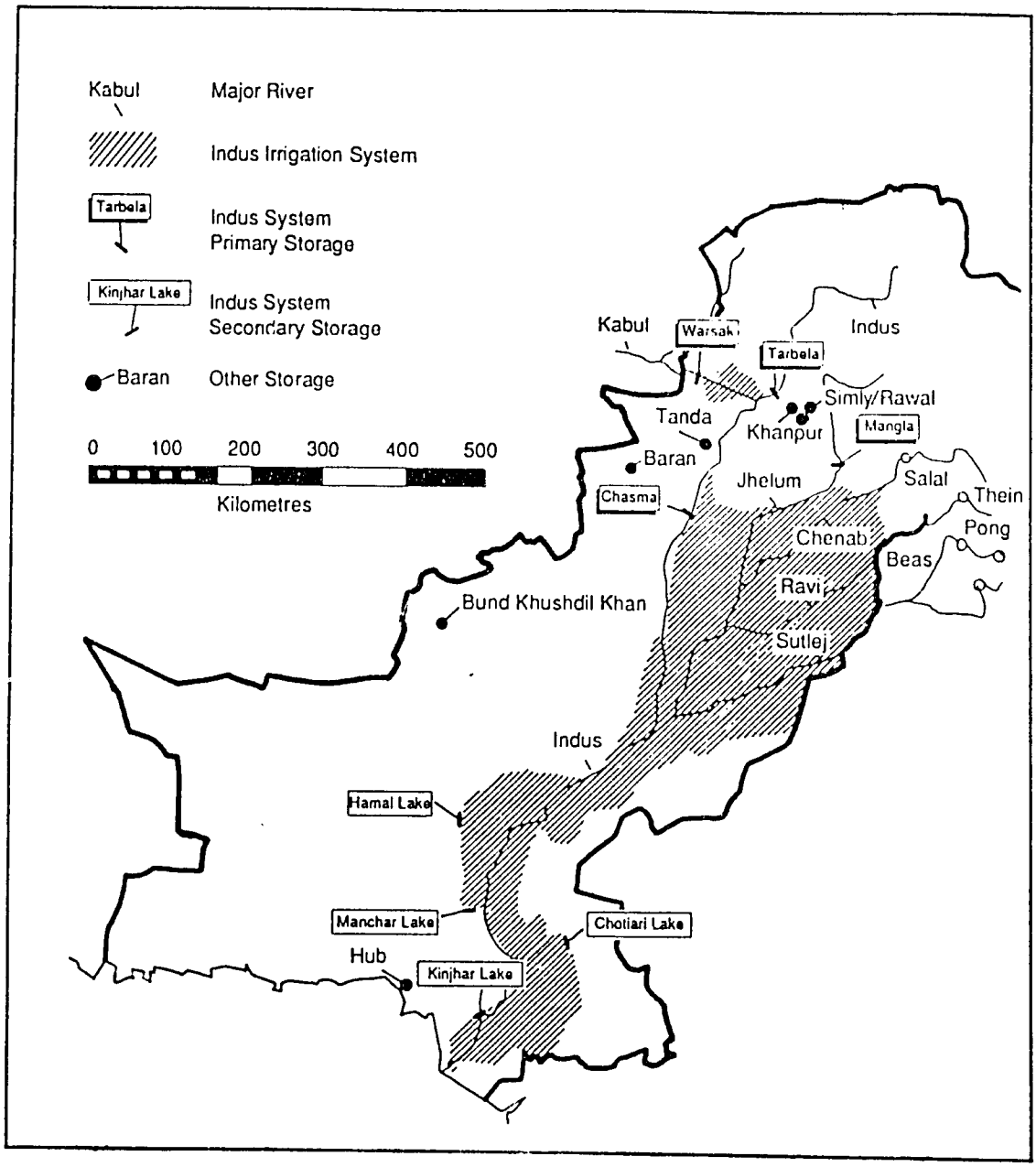
Source: AID (1993)

Pakistan: the Country Context

With an estimated 1991 population of 114 million, Pakistan is the eighth most populous country in the world. The country's 3.1% growth rate is the 13th highest rate of increase among 140 countries having a population of more than one million. It covers only 0.67% of the world's land, contains 2% of the world's people, but in the coming decades will account for 4% for world population growth. Much of this densely populated land is arid or semi-arid. Less than 40% of the country's land area, 34 million hectares, is suitable for agriculture and forestry uses, of which approximately 16.2 M ha are irrigated. Pakistan relies on irrigation from the Indus River and its tributaries for more than 90% of its food and fibre production. The sustainable use of water resources is critical to its future.

Agriculture is the largest sector of Pakistan's economy but the growth rate in this sector has shown wide variation over the last 30 years as a result of periodic flooding and the general availability of irrigation water. Yields of major crops such as wheat, rice, maize, cotton and sugar cane are well below those of other developing countries, and cropping intensity averages below 100% for irrigated land (World Bank 1988).

INDUS IRRIGATION SYSTEM AND SURFACE STORAGE



Source: WSIPS (1990)

The Indus River System

The major source of Pakistan's surface water is the Indus River which originates from glaciers in the Himalayan mountain range. The Indus is joined by five tributaries, the Jhelum, Chenab, Ravi, Sutlej and Beas (see Figure 1). Part of the supply of the Ravi, Sutlej and Beas rivers has been diverted by India as a result of the Indus Water Treaty negotiated between India and Pakistan in 1960. The Kabul River also joins the Indus near Attock. These rivers flow in shallow channels across the vast alluvial plains gently sloping towards south and south-west. The gradients are extremely flat, approximately, two percent in the Punjab and one percent in the province of Sindh. All rivers rise in spring and early summer due to monsoons when nearly two-thirds of the annual discharge passes through. Flows in winter drop by nearly one-tenth of the monsoon season flows.

The Indus River Basin spans nearly two-thirds of the country. The average annual total river inflow is about 17.64 million hectare-meters (ha-m). The total drainage area of the Indus River is 944,500 sq km, of which 415,000 sq km lies outside Pakistan. Nearly 95% of the total flow of the Indus River is used for irrigation, while 3% to 4% is diverted for municipal water supply and domestic consumption. One percent of the total flow goes for industrial purposes.

The Indus Basin is home to the largest contiguous irrigation network in the world. Both perennial as well as inundation canals are part of the network. The present irrigation network comprises of nearly 61,000 km of channels including canals and distributaries. There are 42 principal canal systems with more than 78,000 weir-controlled farm watercourses, 600 km of link canals of various sizes and 16 barrages for water diversions. The two major reservoirs are Tarbela and Mangla with a capacity of 266,200 and 152,920 m^3, respectively.

Each year, 123 billion m^3 of water is diverted into this irrigation network, of which 67.7 billion m^3 are available at the head of watercourses. It has been estimated that anywhere from 5% to 65% of all irrigation water is lost in conveyance to evaporation, seepage and poor management leaving less than 30% for application to crops. Historically, Pakistan's groundwater table has risen on the average at 15 to 25 cm per year since construction of the canal system was begun in the nineteenth century. The adverse environmental impacts of surface irrigation are evident in widespread waterlogging and salinization, loss of forest cover and decreased biodiversity.

Water Supply

There is an absolute limit to the amount of water available

in the Indus Basin; the mean value is 137.2 million acre-feet (MAF). Once in five years the flows are less than 123 MAF. Approximately 104 MAF are already diverted at canal heads. Groundwater is a secondary resource, derived from surface water percolation. Of the annual recharge of groundwater, estimated at 46 MAF, more than 41 MAF are drawn up by tube-wells and used; most of the unutilized recharge is in areas of saline groundwater.

Water-withdrawals increased from 60 MAF to 104 MAF in the last three decades, thanks to projects under the Indus Basin Works Program, supported by massive funding from the World Bank, USAID, and other donors. The Government of Pakistan (GOP) plans to extract up to 114 MAF by extending irrigation to marginal lands before the year 2020. Undoubtedly, coastal mangroves already under stress from reduced fresh water in-flows, and shrimp fisheries 90% of which spent a stage of their life-cycle in the mangroves, will be decimated.

Plans for the extension of the irrigation system have not taken into account competing demands from industry and municipalities. In 1987, only 0.64% of surface and 2.7% of groundwater supplies were drawn for domestic and industrial use. Thus the allocation problem was localized, (mainly in areas outside the Indus Basin, such as the Quetta Valley) owing to frugal domestic use in rural areas (4 gpcd versus 32 gpcd in urban areas) and the nascent stage of industrialization. However, by 2010, if the current trends of industrialization and concomitant urbanization hold (with 85 million people in cities and towns), non-irrigation water demand is estimated to grow from 1.75 MAF to 7 - 11 MAF (5 to 8% of annual inflow).

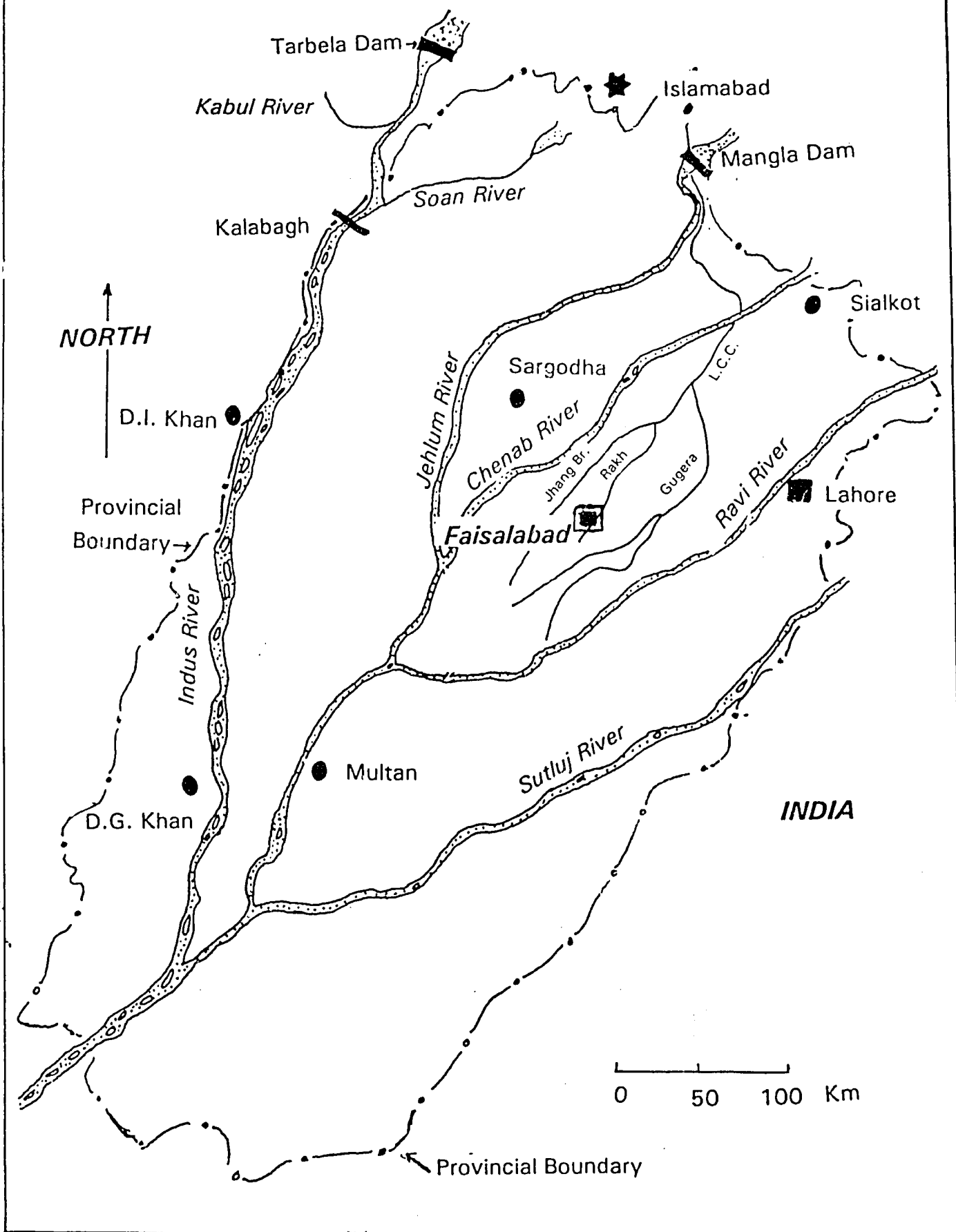
An Asian Development Bank-financed Water Supply and Sanitation Sector Study estimates that 80 percent of Pakistan's urban dwellers have access to water supply but only 52 percent have access to sewerage (WASA 1993). The study further points out that water supplies are generally irregular, with an average of 6 hours per day of supply. Many systems operate with 50% non-revenue (unmetered) water. Although 70 percent of urban dwellers have access to a toilet, treatment and safe disposal of waste water are often lacking (WASA 1991: 1-2, 1-3).

The Case of Faisalabad

Faisalabad District is a 3.6 million hectare jurisdiction of Punjab Province situated in the west of the Province between the Ravi and Chenab rivers (see Figures 2 and 3). Faisalabad is the most populous district of Punjab (estimated at 6 million in 1991), accounting for nearly 10% of Punjab's 60 million (1991 estimate) people. Since the end of World War II, Faisalabad

PROVINCE OF PUNJAB

AND LOCATION OF FAISALABAD CASE STUDY



city has grown steadily as Pakistan's preeminent textile manufacturing center and third most populous city after Karachi and Lahore (see Table 2.2).

Table 1.2
Faisalabad Population Growth Rates 1941-1981

Year	Faisalabad District	Faisalabad (FMC)	Growth*
1941		69,930	
1951	2,152,863	179,000	9.85%
1961	2,683,838	425,240	9.03%
1972	4,241,785	823,344	6.19%
1981	4,689,162	1,104,209	3.32%

*Municipal area growth since previous Census. Source: WASA 1993.

Setting

Faisalabad was established by the British Government of India as the canal colony of Lyallpur following on the construction of the Lower Chenab Canal (LCC) in 1894. Originally sparsely populated with rain-fed agriculturalists, the area was settled by the Colonial Government with inhabitants of east Punjab to bring the newly irrigated lands under cultivation and maximize land revenues. Cotton developed as the principal agricultural crop of Faisalabad and its surrounding districts (e.g., Jhang, Shekupura and Multan).

Following Pakistan's independence from British colonial rule, Faisalabad developed into an industrial center with the growth of textile manufacturing and related enterprises such as dyeing and finishing. In addition, Faisalabad is home to Pakistan's largest ink and vegetable oil manufacturers. In the early 1960s, cotton production in Faisalabad District declined as a result of increased soil waterlogging and salinity, and cotton gave way to more diversified agricultural production, especially with the introduction of improved agricultural inputs during the era of the "Green Revolution". The principal rabi (winter) crops in order of importance are: wheat, gram, oilseed and fodder crops, and vegetables. The principal kharif (summer) crops are sugarcane, cotton, rice, maize, fodder crops and vegetables. As Table 2.3 indicates, agricultural land is intensively cultivated and farmers make extensive use of tubewells to supplement surface irrigation water. The table also points up the extent to which farmers in the district supplement gravity fed irrigation with

Table 1.3
Statistical Profile of Faisalabad District

Land Utilization	
Total Area (hectares)	3,567,535
Cultivable Area	2,914,910
Irrigated Area	2,913,924
Unirrigated Area	986
Forested Area	7,233
Settlement	
Union Councils	163
Villages	610
Farming Households	66,459
Water Supply	
Surface Water	
Canal Water Flow	
Tubewells	
Electric	
Public	429
Private	2,178
Diesel	
Public	7
Private	3,243
Power Take Off	
Public	0
Private	2,195

Source: Deputy Director, Agricultural Extc..sion, Faisalabad (1992). Data exclusive of Faisalabad Municipal Area.

groundwater through the conjunctive use of tubewells. District Agriculture Department statistics indicate one tubewell per 8.7 farm households.

Potable Water Supply

The rural population of Faisalabad District draw their irrigation water from the Jhang, Gugera and Rakh branches of the LCC. In areas of the district where ground water is brackish -- over 75% of the district -- rural populations derive their drinking water from shallow wells dug along the perimeter of irrigation watercourses to tap sweet water that percolates from the watercourses into the water table. Over the past twenty years, the government's Public Health and Engineering Department (PHED) has developed a network of shallow canal perimeter tubewells and canal water sedimentation/sand filtration facilities to meet the growing potable water requirements of smaller cities and towns throughout the district.

Until 1992, Faisalabad city relied on water drawn directly from the Rakh Branch for its drinking water supply because its ground water is brackish. However, as the city's population has expanded, demand for drinking water has outstripped the Rakh Branch supply. To meet the ever expanding demand, the Faisalabad Development Authority (FDA) embarked on a massive scheme to pump potable water to the city from a tubewell field located 30 kms northwest of the city on the banks of the Chenab River.

Management of the Water Sector in Faisalabad

The most important water sector agency in Faisalabad City is the Water and Sanitation Authority (WASA), which is one of the two wings of FDA (the other being the Urban Development Wing). In rural areas, the most important agencies are the Irrigation

FAISALABAD DISTRICT - CASE STUDY

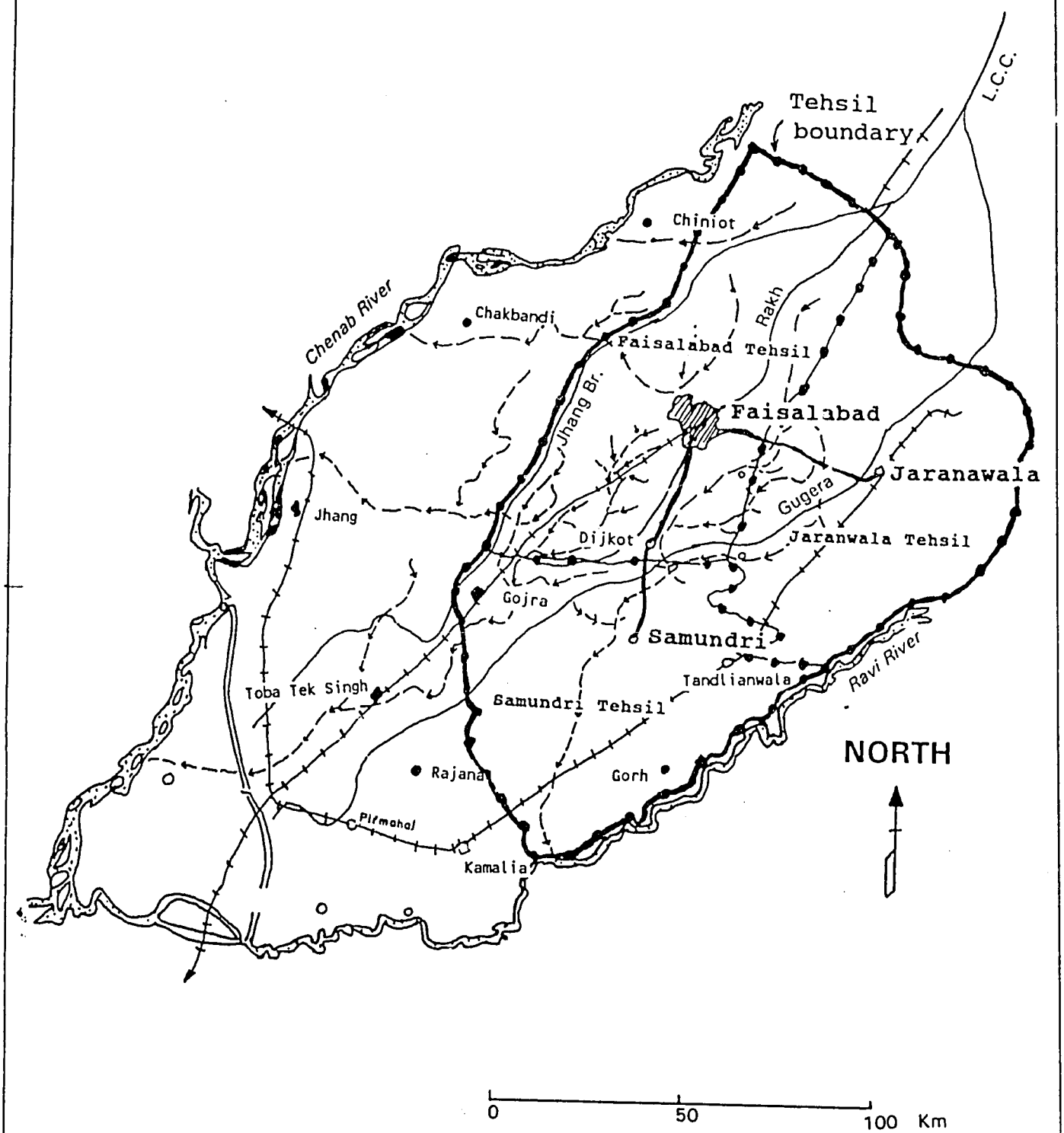


Table 1.4
Government Agencies in the Water Sector in Faisalabad

WASA	The Water and Sanitation Agency of the Faisalabad Development Authority (FDA, an autonomous local body incorporated in 1978, under the Punjab Development of Cities Act, 1976, as a successor to the Lyallpur Improvement Trust).
FMC	The Faisalabad Municipal Corporation, the elected local government of Faisalabad City.
District Council	The elected local government of the rural areas of Faisalabad District.
LG&RD	The provincial agency which provides technical support to the District Council.
PHED	The Public Health and Engineering Department of Punjab Province.
PID	The Provincial Irrigation Department of Punjab.
PEPA	The Punjab Environmental Protection Agency, a provincial agency.
WAPDA	The Water and Power Development Authority, an autonomous Federal authority.

Department and PHED, both of which are provincial agencies. All three agencies operate independently of the local electorate. The elected local government bodies are the District Council (for rural areas) and the FMC (for Faisalabad City), neither of which have a professional staff. Elected bodies are provided technical and managerial manpower by the Local Government and Rural Development Department (LG&RD), which is a provincial agency. The provincial government provides substantial funding to meet the deficits of local agencies, in addition to fully funding the various provincial agencies. Loan liabilities for irrigation and drainage civil works executed through WAPDA are also vested in the provincial government.

Thus the management of water, even at the local level, is effectively in the hands of the provincial government, either directly (through the role of provincial agencies) or indirectly (through large provincial subsidies to local rural and urban agencies). Table 1.4 provides a summary of agencies responsible for water management in Faisalabad. A fuller description of the function of this system can be found in Annex B.

Rationale for Selecting Faisalabad as a Case Study

The study team selected Faisalabad as a case study because it seemed to epitomize the growing conflict between urban and rural sectors in Pakistan over water supply. The city of Faisalabad is unarguably representative of the trend of urban development in Pakistan, with its rapid and extensive industrialization since independence and it concomitant problems of industrial waste disposal and burgeoning demand for urban drinking water supply. At the same time, the agriculture that supports Faisalabad's rural population is almost entirely dependent on the extensive network of surface canals fed by the Indus River System. The size of Faisalabad enabled the team to utilize methods of rapid appraisal that would not have been effective in Pakistan's larger cities, Lahore and Karachi, in the limited time available for data gathering and field visits.

In addition, the selection of Faisalabad as a case study enabled the team to survey a variety of donor-funded activities in the water sector in Faisalabad and its surrounding districts. These activities included: the Irrigation Systems Management Project and Command Water Management Project funded by USAID; the On-Farm Water Management Project funded by USAID and the World Bank and the Asian Development Bank; Phase I of the Water Supply and Sanitation Project for Faisalabad (WASA) funded by the World Bank; and the Fourth Drainage Project funded by the World Bank.

2. WATER QUANTITY

The basic conflict between urban and rural uses of water centers around population growth and its dual consequences for water; the need for more water for crops to feed the population, and the need for more domestic water. The surface supply around Faisalabad is relatively fixed, basically that which comes in the canals. A small additional amount can be derived from the aquifer but much of it is salty. Thus a high price must be paid for additional quantities of water.

The Status of Water Quantity in Faisalabad

The construction of the Lower Chenab Canal off Khanki headworks was sanctioned in 1892 and completed in 1900 with discharges allocated to various branches of the canal. The culturable command area in 1907 was 2,701,173 acres. In 1918 many new minors and distributaries were added; some minors and distributaries were lined and the whole system remodelled and renovated since then. According to 1990-91 estimates the culturable area is 3,054,260 acres under command of the Lower Chenab Canal. Its flow capacity is 12,243 cusecs (8,143 cusecs from Khanki and 4,100 cusecs from a feeder off Qadirabad Baloki Link canal.

Branch canals Rakh and Jhang in Faisalabad district command a gross area and culturable command area of 1,392,411 and 1,149,767 acres respectively as given by Irrigation and Power Department in their 1990-91 estimates. Areas irrigated in the Kharif and Rabi seasons in the district according to the same estimates is 853,694 and 803,268 acres respectively. Sugarcane, cotton, maize, fodders and rice are the main kharif crops while wheat, oil seeds and fodders are main rabi crops.

The gravity drainage system included 456 miles of main drains, 522 miles of branch drains and 198 miles of tributary drains in the Lower Chenab Canal command area with a total catchment of 4,024 square miles.

A total of 2083 tubewells were installed under SCARP-1 in the area under the Lower Chenab Canal, mostly near Faisalabad District. Many of them are still operating. There were a total of 8,235 tubewells in the District in 1982, most of them privately owned and powered by diesel engines or power take-offs from farm tractors (Table 2.1)

Table 2.1
Distribution of 8,235 tubewells in Faisalabad District by ownership and type of power, in 1982.

Ownership	Electric	Diesel	Tractor powered	Totals
Government	475			475
Private	2,120	3,326	2,314	7,760
Totals	2,595	3,326	2,314	8,235

Domestic water supply

Faisalabad was first provided with potable water in 1903 and the water works were gradually expanded. The first supply of filtered water was started in 1939. A partial sewerage system was introduced to provide some drainage facilities to a portion of population (200,000 people) by the mid-1960's. Unfortunately, little or no attention was paid to effluent treatment or the storm drainage system. Growth in population and industrial development made the facilities insufficient resulting in steadily worsening environmental conditions.

A master plan was prepared in 1975-76 and its first stage of development was implemented thereafter. However due to financial constraints, many of the planned sewerage and drainage works had to be curtailed. The Water and Sanitation Agency (WASA) falling under Faisalabad Development Authority (FDA) was created in 1976, and is now close to completion of phase-1 of the 1976 Master Plan. WASA also updated the 1976 Master Plan with the help of the World Bank, publishing the final draft in 1993.

Substantial abstraction of good quality groundwater is difficult in Faisalabad District. Their main sources are a new wellfield along the Chenab River and tubewells along the Rakh Branch canal. Some treated water is also supplied from the canals in limited quantities.

The rural population of the district is supplied with treated canal water in 21 villages while 60 villages have tubewells. However these schemes serve only a fraction of the rural population. Many villages are also getting drainage systems for effluent disposal. Treated water and drainage systems are being looked after by the Provincial Department of Public Health and Engineering.

Currently the domestic and industrial wastewaters from the city of Faisalabad are being disposed without any treatment into

the river systems leading to the Chenab and Rabi Rivers. A treatment plant is however, under construction at present by WASA to treat 90,000 M3/day of domestic waste. Industrial waste water is being discharged into the Paharang and Muduana drains without any treatment, resulting in pollution of Chenab and Ravi waters. Most of the drains improved under phase-1, flow at full capacity without any allocation to deal with runoff during storms.

Water Budget for Faisalabad District

The water budget for Faisalabad District was estimated by compiling the historical and present records of irrigation, river and subsurface flows into the district. To be precise, the flows of sweet water coming to the District by canals or from tubewells were calculated for this budget exercise.

The flows out of the district have not been measured and are not presently being measured so they were not included in the budget. Additionally a water budget for flows into the urban water supply system was compiled from the WASA Master Plan of 1993 and other sources. That water budget is detailed in the following chapters.

Table 2.2.
Approximate Water Supply Budget in million cubic meters applied per year; specifically this is an estimation of sweet water being applied to the surface of the land of Faisalabad District, 1900-2020.

Source	1900	1920	1940	1960	1980	2000	2020
Rakh Canal	0	1,000	1,000	1,000	1,000	1,000	1,000
Jangh Canal	0	3,000	3,000	3,000	3,000	3,000	3,000
Gugera Canal	0	1,500	1,500	1,500	1,500	1,500	1,500
SCARP Deep tubewells SALTY							
Rakh canal tubewells	0	1	10	56	56	32	51
Handpumps-urban	0	0.1	0.2	0.3	0.5	1	1
Handpumps-rural	0	0.1	0.2	0.5	1	5	5
Industrial tubewells SALTY					(30)	(76)	(100)
Private shallow tubewells-urban	0	1	10	20	50	95	100
Private shallow tubewells-rural					10	100	200
WASA deep wells						95	145
Pumping from subsurface drains						260	260
TOTALS	0	5,500	5,520	5,577	5,618	6,088	6,262

Per Capita Fresh Water Availability
Faisalabad District 1980-2020

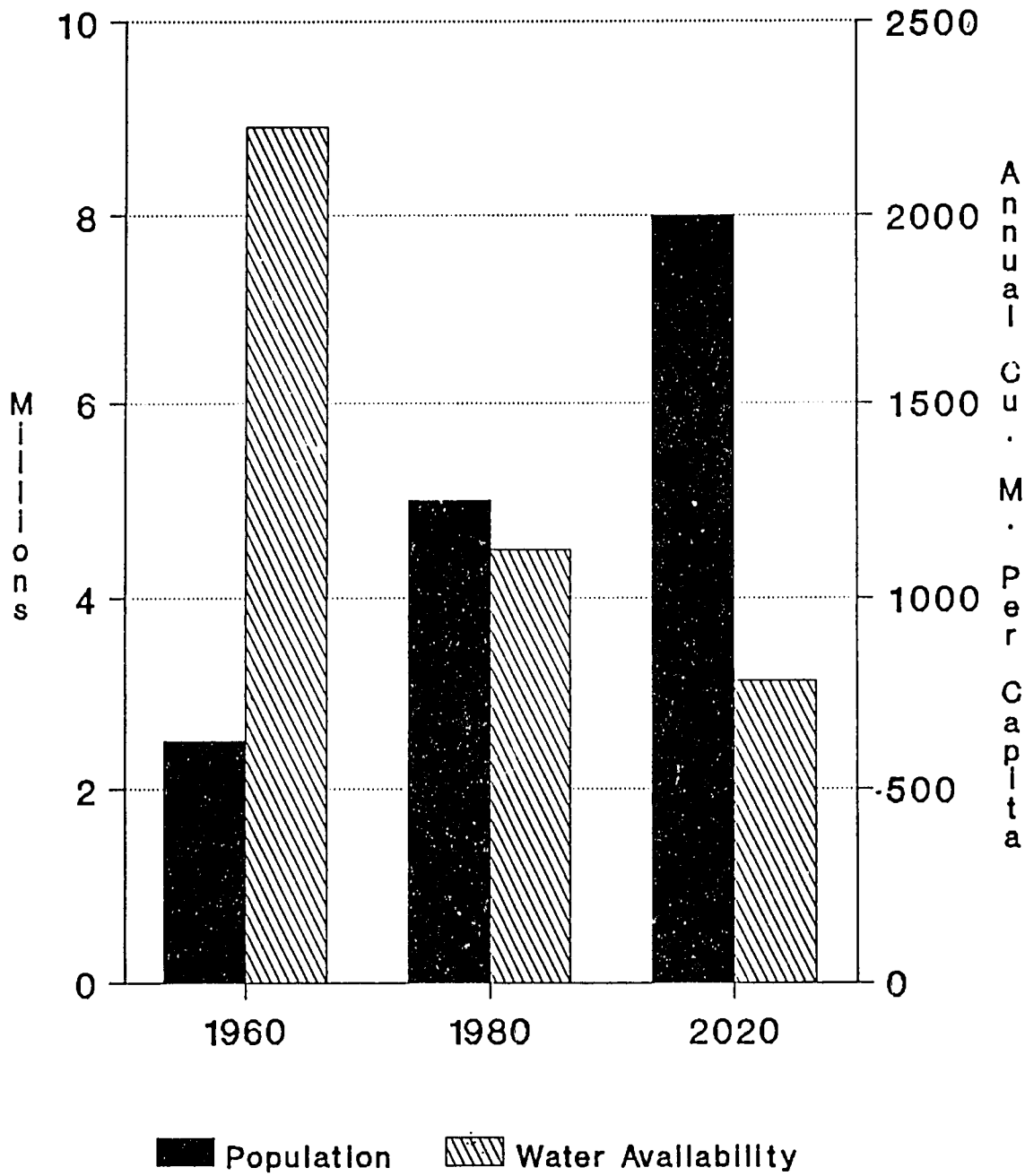


Table 2.3
Total Water Available per person in Faisalabad District, 1980-2020

Year	Population of Faisalabad District	Total Available Sweet Water coming into District in million cubic meters per year	Per capita supply of water coming into District in cubic meters per year
1960	2,500,000	5,577	2,230
1980	5,000,000	5,618	1,124
2020	8,000,000	6,262	783

without appropriate drainage measures.

Environmental Considerations Related to Water Quantity

Use of water for irrigation may have adverse environmental effects such as raising of water table close to the surface resulting in salinity, alkalinity and water logging. These adverse effects on the soil result in reduction of plant growth, reduced yields and lesser vegetation in the affected area.

Faisalabad lies in the Rachna Doab (land between rivers Ravi and Chenab). Soils of the area were formed from soil material which was carried by water from mountains. The deep alluvial deposits were saline long before the introduction of irrigation. After the canals were constructed during the late nineteenth century in the Faisalabad district, salts moved upward close to the surface as the watertable rose from addition of irrigation water. Groundwater use in irrigation through the installation of tubewells which pumped the brackish groundwater also brought salts onto or close to the soil surface resulting in adverse effects on the crop yields and vegetation of the area. Rapid rise in the number of tubewells especially during the last couple of decades in the district has resulted in lowering of water table in some area but has brought more salts to the surface. Many of these tubewells bring up water with total dissolved salt concentrations of 1,500 PPM or more, which has resulted in an increase of overall salt concentration in the rootzone of the tubewell irrigated areas. In addition to total dissolved salts, high sodium adsorption ratio (5 AR) and residual sodium carbonate (RSC) some of these tubewell waters have caused an increased sodicity in the soils irrigated.

Development of alkaline soils in the Faisalabad District as

a result of irrigating with high sodium waters and leaching of water out of the soil profile has even caused more severe problems in the study area. Development of alkalinity due to the removal of salts results in dispersion of soil particles; reduced permeability and reduced aeration. All the above effects result in the reduction of crop yields quite significantly.

The use of fertilizers has grown quite a bit during the last decade. Indiscriminate use of agricultural chemicals is contributing to the chemical pollution of the environment by running off in the water from the fields into the natural channels and also moving downward with the irrigation into the groundwater wherever it is recharged by the former. Also fish and other aquatic life in the rivers Chenab and Ravi into which most of the run off may end are effected adversely due to oxygen depletion from over-fertilization.

Equity and Social/Economic Concerns

Urban versus rural. Urban sprawl over prime agriculture land is a local problem at present. Even in 2010, with 85 million people, urban areas will occupy only 1.2% of the countries 80 million hectares. However, only 12 mha are Class I and II soils. Future urban development should avoid these soils. Presently, short-sighted urban planners and developers tend to prefer these lands, being levelled, for easy installation of infrastructure.

Rich versus poor. Urban water rates do not cover costs; since piped house connections are limited to upper and middle income localities, the policy in fact subsidises the well off, who consume 40 to 150 gpcd. The poor have to pay from water from water carts at much higher rates. In most areas, community standposts work only a few hours a day for two or three days a week.

Present versus future, or ecologically sensitive versus ecologically hardened land. It is criminal to dump toxic and persistent waste on the limited Class I and II soils, and into the fresh water resources of the country. If the Government does not have the capacity to control industrial discharges, it should encourage future industry to locate in abundant desert fringes, with no or little biomass, no fresh water underground, and little downstream agriculture. Such a locational policy would favor Karachi, and Hub/Balochistan over irrigated Punjab, Sindh and NWFP.

Outcome of Corrective Measures

Technological Responses

In response to declining production in Pakistan's agricultural sector, donors came to the support of a program of assistance aimed at rectifying the problems of the Indus Basin irrigation system. This program has had four major foci:

- Conservation of water and redesign of the conveyance system to counter the effects of the division of rivers under the Indus Basin Treaty (the Indus Basin Project, which led to the construction of the Mangla and Tarbela reservoirs);

- Reclamation and control of salinity and waterlogging through the development of vertical and horizontal drainage systems (the SCARP projects);

- Improvement in the delivery of water to farmer's fields (the On-Farm Water Management Projects); and

- Strengthening of the capacity of the provincial Irrigation Departments for sustained and proper operation, maintenance and management of rehabilitated conveyance systems (the Irrigation Systems Management and Rehabilitation Projects and Command Water Management Project).

In addition to government and donor programs, after the 1960's, Pakistan's farmers themselves began to respond to the problems of water delivery through the irrigation system by the installation of private tubewells.

To a large extent, donor response has emphasized engineering and technological solutions: large-scale tubewell projects, dams and link canals, underground drainage and conveyance lining. Even the Command Water Management project, which had as its explicit objective the delivery of technical inputs to farmers to improve agricultural production, devolved into an engineering and irrigation infrastructure project (ISPAN 1993). Table 2.X provides some indication of the level of donor support for water management in Pakistan over the past quarter century.

Table 2.4
Water Management Projects Over the Last 25 Years

Project	Donor	Cost
SCARP/Mardan	World Bank	$60M
	CIDA	$17M
SCARP 6	World Bank	$70M
	ODA	$20M
Fourth Drainage	World Bank	$65M
On-Farm Water Mangement	USAID	$18M
	World Bank	$55M
	IFAD	$12M
	ADB	$25M
	OECF/Japan	$34M
SCARP Transition	World Bank	$10M
Irrigation Systems Management I	USAID	$90M
Irrigation Systems Management II	USAID	$31M
Command Water Management	USAID	$25M
Irrigation Systems Rehabilitation I	World Bank	$28M
Irrigation Systems Rehabilitation II	World Bank	$80
Left Bank Outfall Drain	ODA	$28M
	Saudi Arabia	$52M
	OPEC	$10M
	World Bank	$150M
	ADB	$122M
South Rohri ?	IFAD	$10M

Wastewater treatment and reuse.

Conventional treatment plants are expensive to install and operate. Consequently, there are only a handful of plants in the country; more importantly, most do not operate efficiently. However, there are a number of appropriate technology options, which could be deployed.

The most promising is the Werribbee Farm concept. Since 1880, the Werribbee Farm has applied, and in the process, treated, 2/3rds of the city of Melbourne's sewage waste to grow fodder. Two to three days exposure to sunlight kills all the micro-organisms, (except nematodes). The fodder is hygienic, and feeds 22,000 head of cattle and 100,000 sheep. The health of farm

workers has been monitored, and is better than general health in Melbourne. The wetlands on the farm have become a center of biodiversity in Australia.

The Werribbee Farm concept has been proposed for Karachi sewage treatment. The pre-feasibility study (UNDP) shows it would be safe and profitable to irrigate 4000 acres of desert land in Hub Valley, adjacent to Karachi, with the untreated effluent from STP 1, at Sindh Industrial Trading Estate. The effluent has negligible levels of heavy metals. Nitrate accumulation at the Hub site would not pose a problem since it drains to the sea, while odors would not be blown into the metropolitan area. If found profitable, the project could be extended to Gadap valley, north of Karachi, though here nitrate accumulation in soils would need to be monitored.

Despite the successful feasibility of the Hub valley project, KWSB engineers are still thinking about a Long Shore Outfall, under the instigation of narrowly trained ODA (UK) financed sanitary engineers. There is obviously a need for sanitary engineers and livestock experts to plan and work together.

With such multi-sectoral thinking, the sewage farm concept could be extended to other cities in Pakistan, wherever heavy metals are not present in the effluent. Land should not be a problem, because much of the sewage is presently used to irrigate vegetables, which leads to severe bacteriological contamination, specially of root crops. The issue is to change incentives to grow safe crops with sewage water.

Oxidation ponds are another appropriate option, where fodder land is not available or there is little demand for it. Where heavy metals are present, the sludge may be dumped in pits, where leaching to ground water is not a problem.

Regional Irrigation Efficiencies.

There is not much which could have been done with the canals except an efficient annual maintenance program and continuous remodelling of the canals and fixing of their banks. Their use for cattle bath other than improperly constructed areas for this purpose could have been discouraged as they really cause lot of maintenance problems especially on minors and distributaries. Another improvement in conveyance efficiency could have been achieved by discouraging water thefts and oversupply at the head while making supply more secure and consistent on the tail ends. Seepage losses could be reduced on canals by reducing undesirable weeds and trees which not only cause increase in seepage and leakage but also use some of the precious water from the canals for their growth.

Water in the watercourses could be saved if they are regularly cleaned and maintained by the farmers. Farmers could organize at grass root level and clean and maintain as recommended by the experts. It is estimated that as high as 243 acre feet of water can be saved by proper maintenance and renovation which could irrigate additional 100 acres on an average watercourse. It could also decrease time required to irrigate by as high as 25% along with saving of labour. Renovation and proper maintenance can result in increased acreage under crops and their yields could increase on the average by about 20 percent. This renovation maintenance includes maintenance of proper grades, banks and nakkas; removal of undesirable weeds and trees; discourage their use for cattle grazing and bathing; control of rats; and elimination of cracks. The same applies to farm ditches and field channels which are generally maintained satisfactorily by the farmers.

In order to improve efficiency at the field level, farmers could be encouraged to improve their field slopes by using traditional methods and precision land levelling where feasible. They could be taught to use proper irrigation techniques for various crops such as furrow method for sugarcane, tobacco, maize and cotton, strip for wheat and recommended basin depth and size for rice. Farmers may also be educated about proper number and timing of irrigations for various crops. All these irrigation practices could result in significant savings in water and higher yields of crops for the farmers.

Consumption Pricing; opportunity costs

Irrigation: The price of irrigation water has been kept low. Only half the operations and maintenance costs are recovered, and none of the capital and environmental costs; it has not made sense to conserve. Irrigation prices should be increased gradually to cover not only O&M costs, but also capital and environmental costs. Small price increases will be sufficient to make the small farmer a wise conserver, but big increases to affect the large absentee landlord, make sense, as well as more equitable to levy differential charges, based on total land holdings. The present system based on cropped area encourages over-watering.

Conservation technology/regulation

Irrigation: The first 25% of water losses are in the canals. Nothing much can be done about them. Lining 40,000 miles of canals in the largest contiguous irrigation system in the world is a project beyond the capacities of the richest countries. As wetted perimeter per unit flow is greater in distributaries and watercourse, per cent losses are higher in these components of

the system. Lining of distributary (below 30 cusecs) and watercourses is the option favoured by engineers and departments. However, the results from India, show that brick-lined water channels lose as much water after 8 years of operation as unlined, because they develop cracks and the surrounding soil is dry. Improved lining materials need to developed. More important is to encourage community collective effort for periodic cleaning, and not allowing animals to damage banks.

Industry: World-wide, industry is learning to produce more with less inputs. In the last two decades, the link between industrial growth and corresponding increases in energy and raw material consumption has been fundamentally broken. Specifically, industrial water consumption per unit of production has also declined. Older pulp and paper mills used about 180 cubic metres (6355 cuft) of water per ton of pulp; those built during the 1970s, used only 70. With advanced techniques that keep water circulating within a closed system, and with proper staff training, use rates can be lowered to 20-30 cubic meters per ton of pulp. An integrated steel mill uses about 80-200 tons of water for every ton of crude steel. However, since only 3 tons of water per ton of crude steel are lost, mostly by evaporation, recycling can greatly reduce consumption (WCED, 1987). Such recycling would be pertinent to the Karachi Steel Mills, operating in a zone of water scarcity.

Domestic: In rural areas, water use for washing and cooking is very frugal, only 4 gpcd. Perhaps too frugal for public health. This will remain the case as long as water is hand drawn and carted from wells and pumps. However, with the diffusion of the donkey pump, 1/4 inch piping, and house tap, and perhaps cistern over latrine, there is every reason to expect that rural water use may increase.

The big savings are possible in urban areas, where 40% water supplied is unaccounted for. These are revenue losses; physical water losses are estimated around 17%, owing to leaky mains, pipes, and community taps that are not shut. Again, physical infrastructure (hardware) improvements will play a subsidiary role to institutional development of water supply agencies, and community awareness and participatory action.

Education

Irrigation: Watercourses are classic common property, shared by 20 to 100 farmers. Illiterate farmers have little skills for surveying and grading, and do not have the capital for precision land levelling, sprinkler or drip irrigation. Not being quantitatively minded, they are not even fully aware of the volume of water losses. Environmental costs of seeping watercourses, in the shape of waterlogging and salinity, are

largely externalized to farmers downstream. These are the constraints to organising improved common watercourse management. Government's policy for on-farm water management focused on one-time assistance in lining and no follow-up maintenance further reduces the initiative of local communities.

In these awkward, partly self-inflicted, circumstances, Pakistan must face a sudden inelastic limit on a critical resource. What will happen; will society collapse? In Sahiwal jail, there are a number of nine to eleven year old farm lads, convicted for murder over water disputes. Is there another more hopeful view of the future? Recently some donors and NGOs have started investing in building up farmers' communities for collective management of watercourses, training them in water measurement, surveying, land levelling and watercourse grading, using appropriate tools and techniques. Organizing farmer communities is the only sustainable route to water use efficiency, but the work is painfully slow and small scale. It needs to be extended if the land and people are to survive.

Until the recent completion of a National Conservation Strategy, the government organized by sectors and departments, had not even assembled the databases to address these multi-sectoral issues.

3. WATER QUALITY

There have been two major changes in water quality of surface and subsurface waters for the Faisalabad District in this century: an increase in salts due to irrigation and agricultural activities including biocide applications for pest control; and an increase in organic and industrial contamination due to urban growth. The first change was gradual, becoming widespread about mid-century. The second change was a drastic one, exploding after partition and the development of cotton textile industries around 1970.

Status of Water Quality in Faisalabad

In Faisalabad, prevailing water supply and water quality are areas of concern. Most industries have made their own arrangements for water supply and water quality is generally uncontrolled and unregulated. There are only a few controlled systems for drinking water, and for specialized industrial waste water treatment. The reasons for this situation include the failure of past government efforts to provide safe drinking water for the majority of population, and lack of provision of suitable water for irrigation and industrial process use. Other reasons include lack of policies and budget allocations to develop and investigate appropriate water-uses.

The effects of degraded water quality at a national level of three major natural resources of water: river or surface, groundwater, and precipitation along with the major problems of sedimentation, and waterlogging and salinity are also apparent at an urban and rural level in and around Faisalabad.

Industrial Contamination

Most industries in Faisalabad have made their own arrangements for water supply. The majority of industries are located along the Rakh Branch Canal, Sargodha Road and the Maqbool Road. Historically, the general population and industries have been drawing heavily from the groundwater resource and maintain their own tubewells. As a result, soil salinity appears on the increase, groundwater quality is already quite deteriorated. As a result, the inhabitants of Faisalabad, and especially industry are looking to WASA to provide better quality water.

WASA has imposed aquifer charges on the use of private tubewells within the limits of Faisalabad Development Authority. A survey of current water uses within industries, institutions, commercial buildings and public places was undertaken for Faisalabad, by WASA, to determine the future water requirements.

The major point polluting sources in the Faisalabad region are textile and food processing industries located within the town boundary. Major line sources are the sewerage system including both pipes and open canals. A particularly critical source is the large "Paharang" drain.

A parameter used to measure vulnerability of aquifers to contamination, the DRASTIC Index, is medium to high within the Faisalabad urban area, between 165 and 194. This implies that the aquifer beneath Faisalabad is vulnerable to surface introduced spill and other surface polluting activities. The water quality could deteriorate for this reason. However, the aquifer in this area apart from a confined band along the canals is not potable and only exploited by the industry.

Shallow pockets of fresh groundwater are frequently utilized by installed handpumps and well point schemes. Such sources are prone to both chemical and bacteriological contamination. With the introduction of "on-site sanitation" and the widespread application of low cost sanitation technology, the contamination hazard will increase.

River or surface water pollution from agricultural sources (fertilizers, pesticides, and drainage water) is relatively less significant than water pollution from industrial and municipal effluent in the Faisalabad area. However, the effluent discharge into rivers and smaller channels is increasing and more than likely resulting in serious problem for rivers which drain large industrial complexes in and around Faisalabad.

Few industries or institutions in Faisalabad have a specialized work force dealing with water supply and waste water disposal systems. The awareness of the industrialist with respect to water consumption and operating hours of pumping required was lacking. The WASA survey had to ascertain water consumption from tank capacity against emptying time during peak demand.

Most industries discharge their waste water or liquid effluent into WASA sewers or drains. The amount of waste water is equivalent to the quantity consumed. Little solid waste is disposed because most of it is sold in the market. The WASA survey also highlighted that industries rely more on their own tubewells due to lack of confidence in WASA's ability to provide an uninterrupted supply of water. Industries were understandably reluctant to provide detailed information for fear of increase in tariffs and taxes.

Waterlogging and Salinity

Pakistan is an agrarian economy which relies on one of the

largest weir-controlled canal irrigated networks in the world. In the early 1900s, when the system was constructed, the groundwater table was deep and in dynamic equilibrium (inflow equals outflow) over most of the Indus basin. By late 1930s and early 1940s the water table had risen 15-75 cr over most of the irrigated areas, close to the surface, and the equilibrium was disturbed due to enhancement of recharge by the irrigation system. This enhancement was the root cause of waterlogging. Furthermore, evaporation from the high water table leads to accumulation of salts in the upper soil strata, which results in increased salinity in the root zone of crops. The process of salinization has accelerated in areas near Faisalabad where irrigation supplies have been inadequate to leach down the salts. This problem is typical of many areas of Punjab and Sindh provinces.

By the early 1960s, the extent of waterlogging and salinity was advanced. In Punjab alone, 14% of the total canal irrigated area was out of production and 17% was in advanced stage of deterioration. Fifty percent of the total area of the province was effected to some degree and the process of deterioration continued at 70,000 acres per annum. The arid climate and high ambient temperatures added to the problem.

The increase in salts in the subsurface waters, and the consequent increase in salts in the topsoil was due to the lack of adequate drainage to carry away the irrigation water brought into Faisalabad District by the Lower Chenab Canal and its Jangh, Rakh and Lower Gugera Branch Canals. The canals were constructed in 1894. when the normal water table was about 50 feet below the land surface.

Under the persistent and widespread application of irrigation water by border and flood irrigation methods from this gravity flow system, the water table rose steadily due to seepage of water from the canals and from percolation in the irrigated fields.

Biocide Contamination

Biocidal chemicals used for pest control began to appear in noticeable concentrations in ground water, on fruits and vegetables in the markets in the late 1980s. Most measurements indicated acceptable but rising concentrations of malathion and other widely used synthetic biocides.

The explosive population growth in Faisalabad city at mid-century was greater than the normal increase that occurred throughout Punjab from high fertility and reduced deaths of infants. The decrease in infant mortality was the result of public health programs including the provision of safe drinking water and malaria control. The additional increment in numbers of people beyond the regional increases was primarily due to

migration into Faisalabad of laborers for the textile industries.

The domestic wastewater from this increased number of people, and the industrial wastewater from the new industries was discharged into natural depressions and allowed to flow by natural drainage courses towards the Chenab and Ravi Rivers. The Chak Bandi Drain collected waters from the North-West sector of the city, and the Samundri Drain collected from the South-East sector. Most of Faisalabad's wastewater discharges into the Chak Bandi Drain through the Paharang Drain.

Industrial contamination, especially heavy metals, has begun to appear in water, soil and biota. Careful analysis for industrial solvents and other dangerous organic compounds has not yet been undertaken but the contamination is probably increasing, especially around industries which utilize metal plating processes.

Underlying Causes of Resource Degradation

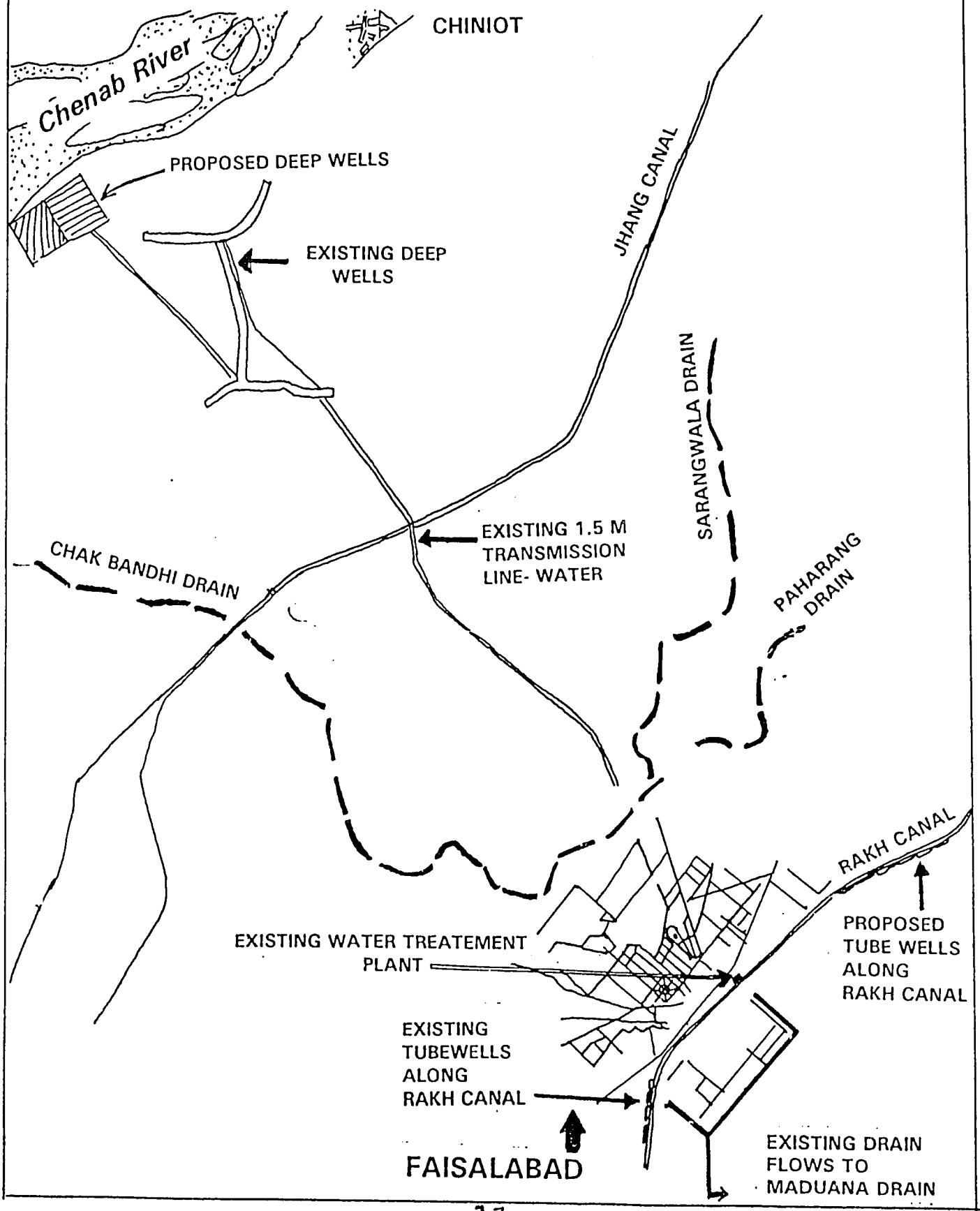
There are over 100 different types of industries and more than 40 institutions, commercial areas, and public buildings in Faisalabad. For disposal of wastes there is no distinction between municipal, industrial and medical wastes. Almost all of the above facilities are discharging their combined wastewater flow into WASA sewers or open/covered drains. These sewers and drains are either not large enough to handle the load or are broken. Consequently overflows occur and affect the low lying areas. Storm and agricultural runoff also enters the sewage systems and severely degrades the quality of receiving waters and the sub-ground aquifers due to leaching.

The only preventive measures factories have adopted to date is the installation of bar screens/strainers on their drains or sewers to reduce blockage. Some have constructed interceptor pits to avoid grit from entering the sewer.

Solid waste from water related industries is saleable, so very small quantities are discarded. Dumping is managed by the Faisalabad Corporation Filth Depot or is placed in open areas. The Corporation Filth Depot also dumps in open areas. Large quantities of medical solid waste are also produced in the hospitals. Only one hospital has its own incinerator, and this is currently inoperative.

Irrigation waters are classified on the basis of their important mineral constituents or in accordance with various relationships computed from the chemical data. This classification is done for the purpose of anticipating the effects of irrigation waters upon soil productivity and crop production. The standards adopted by WAPDA -- on the

URBAN WATER AND SANITATION FEATURES OF FAISALABAD MUNICIPAL CORPORATION



recommendation of Irrigation Department advisors and consultants to WAPDA on development of groundwater for irrigation in the Indus Plain -- are as follows:

- Total salts less than 1,000 ppm: usable for all types of soils and plants;
- Total salts 1,000-3,000 ppm: marginally usable; requires mixing with canal water; and
- Total salts greater than 3,000 ppm: unfit for irrigation.

Mean values for groundwater drawn by tubewells and hand pumps in rural settlements are within WHO standards, but samples collected from dug wells and hand pumps in large cities reveal that 70% are contaminated with sewage organisms. Surface water quality in rural areas varies, depending on source/storage (stream, canal or pond), distance from dumping points and dilution capacity; in urban areas on the existence and standard of operation of water treatment plants. Around Islamabad, 81% untreated and 38% of treated water was found positive for coliform (NIH, 1986). However, treatment plants in Sanghar and Mirpur Khas were found to be poorly operated and possible sources of infection (UNCHS, 1987).

In all cases, much water becomes contaminated before end-use. In rural areas, the main reasons are storage in contaminated vessels and poor handling. Leaking sewers, reverse pressure during supply intermission in water mains, and faulty underground tanks account for the 40% samples below WHO standard in cities.

Pakistan generates 40,000 wet tons of excreta per day (i.e. 15 million tons/year); virtually all is discharged raw and untreated. An estimated 80% in rural areas is deposited in fields; 52% in urban areas is disposed off in sewers and open drains. The remainder is deposited on the roadside or incorporated in solid waste. The prevalence of untreated filth results in pathogens entering the food chain, through irrigation of garden crops, air borne dust, cross contamination of water mains by sewers, or simply by being picked up by children from the dirt of the streets. Half the food is contaminated with pathogens, mainly fecal organisms. One-quarter of all deaths occur below the age of five; 60% of them owing to water-borne diseases. Thirty-three of adult deaths are also caused by water-borne diseases.

From 60-80% of urban domestic and industrial wastewater returns to water bodies. Overloading beyond a limit, which is a function of volume, velocity, and temperature, causes the system to crash, and the stream becomes a sewer transporting rather than treating waste. Table 3.1 provides the approximate assimilative

capacity of Indus Basin rivers at various stretches to receive untreated municipal waste.

Table 3.1
Assimilative Capacity of Indus System Rivers for Untreated Sewage

River	Minimum Flow (cusecs)	Approx. Assimilative Capacity in Terms of Persons	Approx. Population in Vicinity[1] of River Section	
			1981	2003[2]
Indus below Chasma	2,265	1,500,000	108	230
Indus below Guddu	1,770	1,150,000	11	73
Indus below Sukkur	76	50,000	225	439
Jhelum at Railway Bridge, Jhelum	1796	1,170,000	106	234
Jhelum at Khushab Bridge	345	224,000	56	137
Chenab at Alexandria Bridge	117	76,000	63	149
Chenab below Khanki	202	180,000	134	350
Chenab at River Bridge, Jhang	1153	750,000	195	432
Ravi ar Shahdara	400	260,000	2922	7208
Sutlej below Suleimanki	96	60,000	178	410

[1] Actual sewage outflows vary as a function of water supply, climate conditions, soil infiltration, and percent served by sewers and drains.

[2] "No Change" Scenario, National Human Settlement Policy Study, GOP/PEPAC (1986).

Table 3.2 provides the estimated wastewater volumes at outfalls from major urban centers, which are a function of water supplied, climatic conditions, soil infiltration, and per cent served by sewers and drains. Treatment facilities are limited to two partially operational 20 mgd trickling filter plants and an anaerobic lagoon in Karachi against a sewage load of 300 mgd, and a 5 mgd activated sludge plant in Islamabad, plus a handful of package units for some company towns and Cantonments. Comparing assimilative capacities with untreated discharge volumes, it is

clear that massive overloading occurs at several disposal points. Amongst the worst is a discharge of 389 cusecs from Lahore into River Ravi.

Table 3.2
Estimated Sewage Outflows from Selected Cities

City	Sewage Quantities (mgd)
Karachi	300
Lahore	241
Faisalabad	40
Multan	40
Peshawar	18
Hyderabad	15
Rawalpindi	13
Kohat	2.4
Quetta	2

The Seventh Five Year Plan (Vol.II, page 164) proposes 100% sewerage and drainage in metropolitan and secondary cities, and 50% for other urban centers. No efforts for sewage treatment are envisaged, presumably owing to the cost, and disappointing experience in the operation, of conventional treatment plants. A continuation of this policy would make sharpened use conflicts inevitable. The Ravi River below Shahdara would become a sewer for 10 months of the year. Other stretches with acute problems could be the Sutlej below Pakpattan, Mailsi, and Bahawalpur, the Indus below Sukkur and Hyderabad, and the Kabul below Nowshera.

There are virtually no controls applied on waste emissions by industry. A national survey by PCSIR (1985) of 100 hazardous chemical industries showed that only three treated their wastes to acceptable standards. Toxic discharges are reported to have poisoned streams and estuaries, killing aquatic life or rendering it dangerous for human consumption for several miles downstream. Many thousands of acres are reported rendered unfit for crop production. 'Hot spots' are Lyari and Malir rivers downstream of SITE and LITE industrial estates, Karachi, Deg Nullah downstream of Kala Shah Kaku, vegetable lots around Faisalabad, and Multan Canal downstream of Pak-Arab Fertilizer factory. Perhaps of greater concern is industrial discharge to shallow groundwater, as at Kasur, where toxic materials may persist for decades.

If last three decades growth trend (7-8% per annum) continues, there will be 3-4 times as much industry in Pakistan in 2010 as today. How much more effluent will be discharged by a 3 to 4 fold increase in industry will depend on sectoral mix and technology chosen for each sector. Pakistan is moving to more basic industry which is more polluting, but internationally cleaner and more productive technology has become available for each process. A 3 to 5 fold increase in the kinds and volumes of industrial effluent would be a safe guess, in the absence of a strong conservation/pollution abatement policy.

The present pollution readings in sediments and biological material, even in large load receiving ecosystems, are tolerable because industrialization is recent. However, heavy metals, notably mercury and cadmium, are extremely persistent, while organochlorides and some other synthetic chemicals are quite persistent. Such material will accumulate in ecosystems, and a 7% annual growth in discharge volumes does not mean merely 3 times more mercury or cadmium in sediments at the end of 17 years. The pertinent figure is the area under the integral; this will increase 32 times. Fortunately, most of it will remain locked up in sinks in fine sediment, and some plant and animal species are able to limit the amount of metals they retain.

The current average level of application of industrially produced nitrogen (70 lbs/acre) is still far below industrialized country levels (530 lbs/acre) and nitrate contamination of rivers, lakes, and groundwaters is not yet common. The problem is localized to peri-urban vegetable lots. However, the use of inorganic fertilizer has been growing rapidly, and attention needs to focus on improper application which accumulates in seeds.

The effects of the fast growing use of pesticides, herbicides, and fungicides on receiving waters have not yet been reported, unlike cases of accidental ingestion, contact chemical poisoning during application to, and picking of, cotton, and inadvertent destruction of honey bees and other helpful pollinators, owing/spray drift. This could be attributed to paucity of research, as highly persistent organochlorides continue to be used in Pakistan, despite being banned in country of origin.

Domestic pollution

Although no measurements were made of domestic wastewater flow, one can infer the extent of the problem from human population data used in compilation of urban water needs (WASA, 1993). Population within the FMC shows a gradual growth from 70,000 in 1940 to 400,000 by 1960, and then an explosive increase to 1 million in 1980 and about 1.5 million in 1990. Projections from the WASA Master Plan resulted in a population estimate for

2020 of 4 million (see Tables 3.3 and 3.4 and Figure 3.1) .

Table 3.3
Estimates of ultimate maximum flows available from all sources of water for use of urban Faisalabad Municipal Corporation (million m^3 per year)

Source	Volume	Energy Cost	Sweet	Fish-able	Drink-ble
WASA wells in Chenab aquifer	145	high	yes	n.a.*	yes
Wells in Ravi aquifer**	0	high	yes	n.a.	no**
Tubewells along Rakh canal	51	low	yes	n.a.	yes
Indent from Rakh canal	30	very low	yes	yes	yes with filtra tion
Indent from Jangh canal	17	low	yes	yes	yes with filtra tion
Indent from Gugera canal	0***	high	yes	yes	yes with filtra tion
Industrial tubewells in FMC aquifer	76****	moderate	no	n.a.	no
Private tubewells in FMC aquifer	100	low	yes	n.a.	yes
Private handwells in FMC aquifer	1	low	yes	n.a.	yes
TOTALS	344				

* n.a. = not applicable
** dangerous contamination from industries in Lahore
*** indent not obtained from Irrigation Department
**** too salty

Table 3.4
Urban Water Supply available to Population of Faisalabad Municipal Corporation,

Year	Population of Faisalabad Municipal Corporation	Water available for domestic consumption in million cubic meters per year	Available Urban Supply in Liters per capita per day
1981	1,104,000	106.5	264
1991	1,643,000		
PROJECTIONS			
2000	2,500,000	223	244
2010			
2018	3,700,000		
2020	4,000,000*	297	203

Source: WASA (1993)

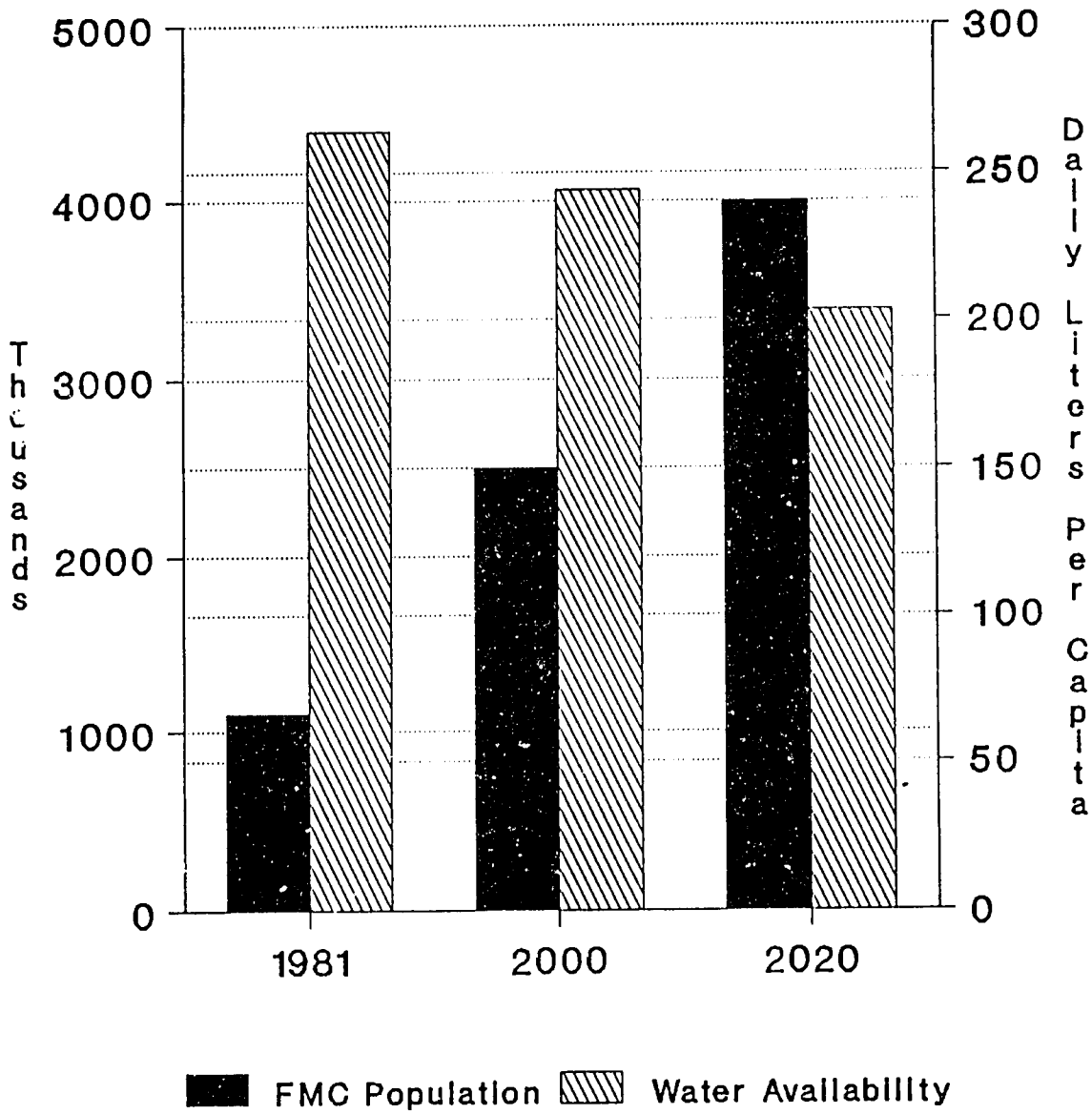
Industrial pollution

The industrial base of FMC is the textile industry, based on the source of cotton fiber from surrounding farms in Punjab. This industry has grown rapidly in the past few decades, both in numbers and diversity of mills, and in size of individual plants. Second in importance are food industries, especially vegetable and cotton seed oil plants.

The current inventory of over 300 individual industrial discharges into the water resources of Faisalabad District was summarized in 1993 for the WASA Master Plan, and supplemental information was provided by the local EPA. In addition to these fairly thorough inventories, a field inspection was conducted in the company of the local EPA official responsible for water pollution.

About 70% of the wastewater generated by these industries is contributed by the textile sector which derive their source water from private tubewells. They all discharge their wastewater into WASA sewers or drains. Some of the major industries have their own sewers discharging directly into Paharang drain. Currently these industries discharge about 30 MCM/yr or 1 cubic meter per second, into surface channels in the Faisalabad District. This

Per Capita Fresh Water Availability
Faisalabad Municipal Corporation
1981-2020



amount will probably double by the year 2020.

Maqbool Road Industries and Satiana Road Drain

Our field tour began on Maqbool Road where a large group of textile finishing and dyeing industries are located, including Saftia Textile Company. Their wastewater was purple and red, flowing at about 50 liters per second into a covered WASA drain which carried wastewater from several similar industries in the local association out to Satiana Road.

A few kilometers East and downstream of Maqbool Road, a WASA pumping station brought up 400 liters per second of industrial waste and 200 liters per second of domestic waste, pumping them into a raised open drain which then flowed by gravity along Satiana Road to Mahduana Drain. Immediately below the pumping station was a wastewater flow of Zim Zam Textile Mills into the gravity drain. A few more industries discharged into this drain before it made its way through agricultural land, crossing under a distributary and then passing a government fish hatchery before it continued on to its confluence with Mahduana Drain.

The government fish hatchery raises six species of carp including chinese grass carp which they breed by hormone injections and then raise the fry until they are 10 cm long. They also raise silver carp and other species. Their primary production goes to government fish farms, and they fill as much of the private demand as they can. They have suffered some ill effects from the toxicity of the industrial drain which passes near their ponds. The wastes have apparently damaged plankton production in some of their ponds.

Kohinoor Textile Mills and Jaranwala Road

An open drain began across the street from the entrance to the Kohinoor Textile Mills, receiving wastewater from Kohinoor, Lyallpur Chemicals and other industries in that area, as well as domestic sewage. This drain was overflowing into roadside depressions, causing a large area of stagnant sewage between the road and a residential area to the South. The drain flowed East to Mahduana drain, collecting wastewater from Refhan Oil Mills on the way.

Abdullahpur Industrial Area

In this area to the north of the bridge on Jaranwala Road, several small textile printing industries dumped their wastewater out their front gate onto the road. It flowed to a depression by the railroad tracks and caused the buckling of one line of track. Further North were several large lagoons formed by uncontrolled discharges from several ghee industries.

Sargoda Road and Sarang Wala Drain

North of the Sheikpura Road intersection with Sargoda Road, the road passes over Pharang Drain which receives industrial and domestic wastes but is covered. Slightly further North is Sarang Wala Drain which is open and part of the natural storm water channels. Sarang Wala Drain receives wastes from pipes discharging directly to the drain from several industries along its banks, including Faisalabad Oil Refinery, Sargodha Spinning Mills and Dawood Textile Mills.

Agricultural Pollution

The use of fertilizer has increased significantly in Pakistan over the last three decades. About 60% of fertilizer used is applied in the rabi season (when the wheat crop is sown) and the balance is consumed in the kharif season (when cotton, rice, sugarcane, and maize crops are planted). The offtake target of fertilizer for the current year has been fixed at 2.04 million nutrient tons, which is 7.8% higher than the offtake in 1989-90. In the absence of any specific analysis on the amounts of fertilizer and pesticide residues in agricultural runoff or extent of contamination of surface or groundwater, 7.8% increase in fertilizer consumption would more likely increase the contamination due to residues by the same proportions.

Biocide Contamination

The amount of biocide used in agriculture in Faisalabad District has increased steadily since the Green Revolution of the 1960s. In addition large amounts of DDT and Malathion were used and distributed throughout the District under the Malaria Control Program which lasted from 1960 to 1992.

The largest chemical group applied for agriculture are the organophosphates, followed by rapidly increasing pyrethroids (Table 3.2). There has been a recent reduction in the use of chlorinated compounds. Since 1980 the amount of pesticides used in Punjab has increased over six times, including a ten-fold increase in the cultivated area over which they are being applied.

Traces of malathion and other biocides are appearing in the groundwater and aquatic habitats of Punjab and Sindh Provinces. In 1992 the concentrations discovered in Faisalabad District were still below critical concentrations, but presented a clear danger to human health and the environment if they continue to double every five years, in proportion to the rate of application (Table 3.5).

Table 3.5
Proportion of Synthetic Biocides Used in Agriculture for Pest Control

Major chemical group	1985	1990
Chlorinated compounds	10%	3%
Organophosphates	60%	56%
Carbamates	4%	5%
Pyrethroids	26%	36%
National Consumption in metric tons annually, of active ingredients	2,172	4,316

Institutional Issues

The major undesirable effects witnessed in urban and rural areas in the context of water supply and its quality include the following: inadequate and irregular supplies; the marginalization of tailend farmers (in rural areas) and katchi abadi dwellers in the City; inadequate sanitation and drainage in both urban and rural areas; deterioration in the quality of the resource (through salinity and the discharge of industrial and domestic waste); and, the transfer of polluted water to down-stream users.

The major institutional reasons for the preceding problems may be summarized as follows:

- The absence of a service orientation in concerned agencies toward the urban and rural users of the resource, and the lack of accountability of these agencies to the users; resulting in:

- User dissatisfaction with the services provided and their consequent refusal to contribute more toward the investments and O&M required in the water sector.

- Lack of experience and expertise in integrated planning for urban water supply, sewerage and drainage.

- Lack of expertise in integrated planning for surface supplies and the aquifer.

- Absence of local government mechanisms to recognize and manage the growing size and population of the katchi abadi.

- Absence of a market for municipal bonds through which local government can raise funds for infrastructure investment.

- Absence of mechanisms through which local businessmen and philanthropists could forge partnerships (among each other or with the government) for investing in their City.

- Lack of awareness of resource pollution issues and solutions.

- Lack of mechanisms (including inter-provincial mechanisms) for imposing penalties on up-stream polluters.

- Severe lack of procedural and financial flexibility in all agencies, particularly the Provincial agencies.

Resource Protection Responses

Legislation

Laws and Regulations for Water Pollution Control
The legal framework for controlling water pollution in its modern form does not exist and comprehensive guidelines have are not yet established. Although, the Pakistan Environmental Protection Ordinance (PEPO) was promulgated in 1983, in terms of provisions, it provides more for control of air pollution than other aspects of environmental protection. To date it is practically ineffective due to lack of delegation of necessary powers to the Provincial Environmental Protection Agencies (EPAs).

In existing form, the following legislation applies to control of water pollution:

- The Pakistan Penal Code (1860) authorizes a fine of up to Rupees 500 or three months imprisonment or both for voluntarily corrupting or fouling public springs or reservoirs so as to make them less fit for ordinary use. The Act is rarely applied.

- The Canal and Drainage Act (1873) also prohibits corrupting or fouling of canal water imposing fines of Rupees 50 or 1 month imprisonment or both. In the amendment the penalty is Rupees 200 or 3 months imprisonment or both.

- The Factories Act of 1934, includes the Provincial Factory Rules. These are primarily concerned with the working conditions, but Clause 14, heading "Disposal of Wastes and Effluent," states that (a) effective arrangements shall be made in every factory for the disposal of wastes and effluent from manufacturing process," and (b) the Provincial Governments may make rules prescribing the arrangements to

be made under sub-section (1) or requiring that the arrangements made in accordance with that sub-section shall be subject to the approval of such authority as may be prescribed. Penalties are Rupees 500.

The Punjab Local Government Ordinance, 1979, authorizes the Urban Local Councils to provide for and maintain an "adequate system of public drains," and regulate private drains. [section 1] Other provisions require commercial building occupants to be responsible for waste removal or the Urban Council can undertake necessary disposal and recover costs.

Waterlogging and Salinity

The deep tubewells installed in response to the rapid increases in area of waterlogged soils and consequent increases in salts in the topsoil, were installed in large numbers starting in 1960, with a total of over 2,000 installed by the time the initial program ended. These tubewells lowered the water table to about 15 feet below the land surface, by 1970, alleviating the waterlogging and slowing the rate of salt build-up in the soil However this did not reduce the amount of salt in the subsurface waters, and increased the concentrations in the drains, natural streams and rivers. Because attempts were made to use the effluent from these tubewells for irrigation, there was an increase in soil salinity even without the waterlogging, in some areas. However one beneficial effect of lowering the water table was the decrease in flooded areas which had been breeding sites for malaria mosquitos.

Industrial Pollution

The WASA master plan proposes generally acceptable measures to encourage industries to reduce their waste production, recycle valuable resources, and eliminate toxic materials from their discharges. They also propose the establishment of separate industrial wastewater treatment plants, in areas of the city where industries are concentrated. However the industries are not all located in these areas so many of them will be connected to the sewers which flow to the "domestic" sewage treatment plants. In addition the industrial areas also have homes and other institutions in them, thus domestic waste will go into the industrial treatment plants.

The sewerage plan utilizes the basic natural drainage channels and streams which were in existence before the city developed. After heavy rains the sewers will thus contain rain water runoff, as well as the mixed industrial and domestic wastewater flows. The sewers are designed to take fairly large storms but inevitably as the city grows, there will be frequent overflows when the sewage backs up into streets and residential

areas, similar to the present situation.

Resource Management Actions

In the Faisalabad City, the most important response to urban pollution to date has been the Provincial Government's decision, in 1978, to transfer the entire responsibility for water supply, sewerage and drainage from the elected local government (the FMC) to the FDA (in particular, its WASA). This decision was intended to improve the efficiency of the system, since autonomous entities such as the FDA are perceived in Pakistan as more efficient than elected local governments. While efficiency may have improved in the short-to-medium term, the result is a management system that is independent of the City's electorate (except insofar as certain Members of the Provincial Assembly sit on the Board of the FDA).

Since the FDA's creation, the most important official event in the City has been the formulation of a master plan for environmental infrastructure (water supply, wastewater treatment, sewerage and drainage). This was completed in March 1993 under contract to the World Bank, which is appraising the investment possibilities indicated therein. The people's own response to water shortages has been seen through private sector developments: industrialists have sunk their own tubewells, while an informal sector has developed to cater to the needs of lower-income groups. Similar private sector responses, however, are not much in evidence for sewerage and drainage.

In the rural areas, a variety of surface and vertical drainage projects have been undertaken, all of them with donor assistance. The largest of these is the Drainage IV Project funded by the World Bank and ODA (of U.K.), which is the most important water sector investment in the District in recent years. Smaller, donor investments in watercourse renovation have also been undertaken with the aim of reducing water losses below the <u>mogha</u>.

The most notable omission from official responses so far has been the failure to put the operation and maintenance (O&M) systems for rural and urban water (including irrigation water) supply and drainage on an institutionally and financially sound basis. However, some promising steps have been proposed recently, but in all cases the initiative appears to have come from donor agencies. In the urban setting, the Master Plan prepared under contract to the World Bank calls for an independent and strengthened O&M Directorate in WASA. The translation of this recommendation into practice remains to be seen. In the rural setting, a comprehensive proposal has been floated by the World Bank for discussion with the Government, for converting the PID into an autonomous authority which will have

the power to raise its own finances. Official reactions and implementation details are not yet known.

Effectiveness of the Response

The primary responses to the problems of industrial and domestic pollution have been the creation of the EPA at both National, Provincial and local levels, and the completion of a Master Plan for Water and Sanitation for Faisalabad Corporation by WASA.

The EPA is only barely beginning to respond, almost 10 years after its creation. The First Phase of the Master Plan for Water and Sanitation is nearing completion, the Water Supply being finished last year and the Sewers scheduled for completion for next year.

Alternative Responses

Industrial pollution

From centuries of experience in the Eastern cities of the United States of America, especially older cities such as Boston, the painfully learned lesson has been that the best way to avoid severe problems of ecological contamination, and to minimize the costs of sewers and sewage treatment, is to maintain storm sewers completely free of domestic and industrial wastewater. Once these materials flow into the natural streams, rivers, harbors and oceans, permanent damage results.

Furthermore the wastewater treatment plants in these older cities had to be of unusually large size because they have to treat the volume of rain water as well as the domestic and industrial flows. This is an extraordinary extra expense which should be avoided in Faisalabad by maintaining the sewage free from rainfall storm flows from the very beginning.

Industrial wastes, especially those containing toxic materials, are too difficult for municipalities to deal with. The industries should be encouraged and required to work toward a completely closed industrial plant where they use all of their own wastes, or dispose of them in an acceptable manner without discharging them into natural water channels, or even into the municipal sewers. This requirement would be, in effect, the establishment of a **zero discharge policy for industrial wastes.** While sufficient time should be given to the industries to work toward this goal, it should be established at the outset in order to simplify and rationalize the entire process of pollution reduction.

If the Faisalabad office of the EPA has to measure and analyze all of the wastewater discharges from the 300 industries, and also put each one of them on notice that they must treat their wastes to some effluent or stream standard, it would take an enormous staff of over 100 people, working about 5 years to make the first round of surveys. Complex chemical laboratories and enormous numbers of repeated analyses would be required for heavy metals and industrial solvents, as well as other dangerous synthetic chemicals which might be used in industrial processes. The amount of work is simply too much to require of such a small and weak agency. Establishment of a 5 or 10 year goal of zero discharge makes monitoring and enforcement much simpler, and puts the difficult tasks where they belong, on the industry and their technical staff, not on the EPA.

Policy and Planning

Of the institutions involved in the management of water in Faisalabad District (see Table 1.4), organized planning departments or units exist in the WASA, the Irrigation Department and WAPDA, that is to say, at the local, provincial and Federal levels. The thrust of planning at these as well as other agencies (such as PHED and the elected bodies) has been on capital budgeting for infrastructure, that is to say, the annual (for five-yearly) allocation of available funds between various civil works projects. The main influence on this kind of planning is political, with crisis management needs contributing occasionally, as well. The main result, predictably, is lopsided attention to drinking water supply for influential constituencies, with considerably less attention to industrial users and the minority that constitutes katchi abadi, and no attention to quality and conservation issues.

A better and more adequate approach to local-level planning would include the following:

- A zoning plan that facilitates the separation of wastewater streams;
- A service plan with phased targets by locality and sector (water supply, drainage, etc.);
- A monitoring plan with indicators of consumer satisfaction, and of financial and environmental sustainability;
- A staffing plan corresponding to the requirements of the service and monitoring plans;
- A financial plan showing sources and applications, and reflecting a clear vision of financial sustainability; and;

- A communication plan for an open and effective dialogue between the agency and the general public on all the aspects listed above.

- In addition, a (corporate or institutional) strategic plan is needed to give direction and coherence to all of the above.

The essence of this kind of planning would be "planning for, and with, the users", so as to impart community ownership to the plan, enhance its legitimacy (and possibly broaden the beneficiary base), and thereby attract community resources for cost-sharing. The premise behind this statement is that community contributions (as user charges, local taxes, philanthropic donations, etc.) are not likely to be volunteered by the public, unless the public is effectively involved in the decision making. In other words, the cost-sharing which is so essential for financial sustainability is not possible without power-sharing.

While service delivery in the short-term can probably be managed with good local level planning that engages local community participation, longer-term quality and conservation issues also need attention at higher levels for planning and monitoring.

The central problem of conservation that needs to be addressed by planners is the valuation of a finite resource (water), that can be drawn in variable quantities from multiple sources (surface supplies and various groundwater extraction technologies, each with its own cost), facing a rapidly growing demand from competing users in the economy (farmers, households, commercial establishments and industrialists). This problem statement contains all the important dimensions of the water sector - resource conservation, financial sustainability of the management system, and equity among users - but its key element is to determine the environmentally sustainable level of withdrawals (per unit of time) from each source. A considerable amount of analysis, dialogue and planning is needed at the local, provincial and national levels, before conservation measures (whether revolving around pricing, technology or infrastructure) can be implemented on any significant scale to bring the demand for water to its sustainable level.

Attention to quality issues is also required at the provincial and national levels, in the first instance, to monitor surface channels and the aquifers. In this connection, an urgent priority is to strengthen the role and capacity of the Punjab and Federal EPAs within their respective domains. These agencies would then need to go beyond monitoring, to recommending and enforcing standards across local and provincial jurisdictions.

Policy and Institutional Reform

The absence of a service orientation toward users, their lack of involvement in decision making, and the lack of accountability of water sector agencies to users and the local electorate, have led to widespread alienation and distrust among the citizens. There is, therefore, no sense of ownership of the City's resources and problems among either its elites or its less privileged inhabitants, and little obligation to contribute towards the cost of managing the water resource in an efficient and sustainable manner. The result is a system that neither delivers service nor recovers its cost.

Building the legitimacy of the service delivery organizations must be the essential first step leading to two, equally desirable directions, namely, the environmentally sustainable use of water, and financially sustainable management systems. The institutional reform that is needed is premised on the following: that neither resource conservation nor cost recovery is possible without popular participation. This means that official agencies need to open up their processes of planning and decision-making so as to effectively engage local communities.

Since reform is often perceived in terms of loss of control by official agencies, only those agencies whose leadership is genuinely committed to popular participation should be deemed to be deserving of donor support. This means that "project areas" should be chosen not so much on criteria relating to "need" as "willingness to change". While the "need" for donor support is often determined through poverty indicators, rates of return, or other quantitative measures, the assessment of the potential to innovate is largely a subjective judgement. It requires, in particular, development administrators/project officers who can "walk their beats" in a province or country, and assess the potential for change among community leadership.

Methods for selecting project officers and project areas are, therefore, the foremost aspects of institutional reform for interested donors. Only then can donors engage in a meaningful dialogue for policy change and institutional reform with aid recipients. Once these pre-requisites are fulfilled, a number of important directions for policy and institutional reform can be pursued to good effect.

The building blocks of institutional reform are all found at the local level, among the insolvent service agencies looking for financial support, the under-privileged and ill-served whose basic needs are not being met, and the privileged and affluent who are driven by charity, fear or enterprise. They all depend on each other, and they are the elements of a natural partnership for sustainability. The donor's first challenge is to get them

together in a project.

The second challenge is to get them all to change. This means providing technical assistance not only to official agencies, but also to organizations of citizens (farmers and katchi abadi among them) and industrialists who need to organize and motivate their membership, and elicit ideas and resources from them. This leads to the third challenge, that is, to change the conventional notion of technical assistance, to make it conform to the needs of the problem and the recipient, so that, for example, local government officials from other countries should help the recipient with local level planning; successful urban NGOs from Third World settings should help the katchi abadi inhabitants, leading private sector philanthropists should advise local businessmen interested in helping their city, and so on. The conventional notion of technical assistance that is organized around sector specialists has been a failure in inter-cultural communication and should be abandoned. Organizational experience should be preferred to subject matter experience.

A preliminary agenda for institutional reform of service delivery organizations must be an integral part of a local partnership initiative. The Faisalabad case study suggests that the planning process followed by water sector agencies is, in essence, a capital budgeting exercise revolving around political decisions on the allocation of available funds to various, presumably influential constituencies, in aid of enhanced water supply. Aspects of service delivery, conservation, quality and other long-term concerns are omitted from what is currently understood as planning. A more adequate approach to planning for water management in both urban and rural areas would require each agency to prepare and implement the following: a zoning plan to facilitate the separation of wastewater; a phased service plan that has been discussed with the local community; a monitoring plan with environmental, financial and service indicators; a staffing plan for the above-mentioned requirements; a financial plan with all possible sources and applications; a public interest communication plan to engage the community in a continuing dialogue; and a strategic plan to give direction and coherence to all of the above.

Together with project-level support for the creation of local capacity and partnerships, a donor would have to engage in dialogue with higher-level governments, especially (in the Pakistani context) the provincial government, which dominates the management system for water supply, irrigation, sewerage and drainage, and operates an EPA. This statement can be motivated in the following way: experience has shown that established procedures and policies often become binding constraints on project performance and outcomes. Put differently, the limits to institutional reform of local agencies are often found in provincial (or even national) policies. Another reason for

engaging provincial agencies is that the resource itself, whether stored in the aquifer or flowing in surface channels and drains, cuts across local jurisdictions. For these reasons, the interested donor would take a sectoral approach, in which a local project is one essential component, and provincial policy dialogue and capacity building another.

Judging from the Faisalabad case study, strengthening the role and capacity of the Punjab EPA to monitor quality and enforce standards across local jurisdictions would be an important part of a sectoral approach to donor assistance. The needs for policy dialogue at the provincial level are also partly evident from the Faisalabad case. Foremost among these is the need to get local agencies to be accountable to local communities rather than the provincial government. Other constraints that could be the subject of dialogue at the provincial level include procedural and financial rigidity, and the absence of a municipal bond market.

Above the provincial level, the need for strengthening the role and capacity of the Federal EPA is also suggested by the Faisalabad case study. The specific need is for the Federal EPA to monitor the quality of channels and aquifers crossing provincial jurisdictions, and enforce sanctions on polluters.

At all levels of government, much greater attention is needed than hitherto given to conservation issues. The central problematic of conservation that needs to be addressed is the valuation of a finite resource (water), that can be drawn in variable quantities from multiple sources (surface supplies and various groundwater extraction technologies, each with its own cost), facing a rapidly growing demand from competing users in the economy (farmers, households, commercial establishments and industrialists). This problem statement contains all the important dimensions of the water sector -- resource conservation, financial sustainability of the management system, and equity among users -- but its key element is to determine the environmentally sustainable level of withdrawals (per unit of time) from each source. A considerable amount of analysis, dialogue and planning is needed at the local, provincial and national levels, before conservation measures (whether revolving around pricing, technology or infrastructure) can be implemented on any significant scale to bring the demand for water to its sustainable level.

4. RELATED ENVIRONMENTAL CONCERNS

This chapter examines the consequences of prevailing water resource management practices for related environmental concerns, particularly energy production and consumption, public health, natural disaster management and biodiversity.

General Environmental Concerns

Loss of Hydro-electric Energy Capacity

About 77 percent of commercial energy produced in Pakistan, including the transportation sector, is obtained from oil and gas, 18 percent from hydro-electric power, 4 percent from coal and 1 percent from Liquid Propane Gas and nuclear sources. The share of oil in the total energy supply is 42 percent and that of natural gas is 35 percent (1991-92).

The installed electricity generation capacity increased from 8,508 Mega Watts (MW) during 1990-91 to 8,928 MW in 1991-92, an increase of 5 percent. The total installed power generation capacity in the country is 7,053 MW, of which hydro-electric capacity is 2,897 MW and thermal is 4,156 MW. The thermal power is largely dependent upon the limited natural gas reserves and imported oil.

The overall mix of hydro-electric and thermal generation till 1991-92 has been optimized at a nearly equal ratio. This saved foreign exchange required for the imported oil and kept the price of energy from sky-rocketing. However since no new hydro-electric capacity is coming up in the near future it may not be possible to maintain this ratio of hydro-electric to thermal generation as the existing reservoirs of Tarbela, Mangla and Chashma become shallower due to sedimentation. The future demand is likely to be met from thermal power generation which would certainly be more expensive due to dependence upon imported oil.

The storage and power capacity of the existing hydro-electric reservoirs is steadily decreasing due to their filling with sediment. Sedimentation is a major problem in the upper portions of rivers in Pakistan. Suspended sediment concentrations in major rivers range from a few parts per million (ppm) during low flows to 10,000 ppm during high flows. Sediment content of tributaries in arid areas can also be extremely high: for example, the highest sediment concentration observed in the Gomal River (D.I.Khan Division, NWFP province) at Kot Murtaza was 197,000 ppm. Current observations indicate that more than 43,500 hectare-meter (ha-m) of suspended sediment enter the Indus System every year, but only about 18,500 ha-m pass Sehwan on the Lower Indus. This means that approximately 25,500

ha-m are deposited every year within the system, particularly in reservoirs and irrigation channels.

The Indus river carries the fifth highest sediment load in the world. In the Tarbela Dam catchment area, soil erosion is measured at 2 to 4 kg per square meter or 20 to 40 tons per hectare, annually. An estimated 167 cubic meters of sediment are deposited annually on each square kilometer of Tarbela catchment area. In the first 10 years after construction of Tarbela Dam (1975-85), the reservoir lost 14% of its storage capacity or 1.6 million acre feet (MAF). Tarbela is likely to lose another 15% in the second decade (1985-95). In the Mangla Dam catchment area, rate of sedimentation has decreased from 42,000 acre-feet per annum in 1950-60 period to 34,143 acre-feet per annum in the 1967-83 period as a result of a farmer-oriented multi-sectoral conservation project. The methods to control sedimentation are well-known in Pakistan for more than 30 years. Application of these methods to Tarbela catchment area is difficult because there the River Indus passes through a high-relief terrain to which improved cropping and watershed management practices cannot be applied with much success.

There is variation in the estimated rates of decrease in capacity of these reservoirs, between the following three sources: WAPDA, the World Bank, and Kalabagh Consultants (KC).

Table 4.1
Declining Storage Capacity of Existing Reservoirs in Billion Cubic Meters

Reservoir Live Storage Capacity	Tarbela	Mangla	Chashma	Total
Designed	11.47	6.59	0.62	18.68
Actual in 1988	10.93	6.02	0.54	17.49
Projected for 2000:				
WAPDA	10.31	5.7	0.28	16.29
W. Bank	7.03	5.27	0.62	12.91
K.C.	9.25	-	-	-

This reduction in storage would result in reduced regulation capability of reservoirs and hence decreased water availability for irrigation use in late kharif (September), and in rabi and early kharif ((April-June). Most water programs including SCARP and others are also likely to be affected by the energy projections based on the change in the source of power generation from hydro-electric to thermal. **As electricity becomes more expensive the cost of pumping and operation of tubewells will go**

up.

In Faisalabad, there are 6,852 tubewells of which 2,947 are driven by electricity and 3,905 are diesel driven, utilization is 22% and total power requirement is 44.49 million kwh of electricity and 6.5 million gallons of diesel.

Health Impacts

Epidemic malaria was a major health impact of the original irrigation program because of subsequent waterlogging. The first major epidemic in the Punjab, causing about 300,000 deaths, occurred as early as 1908, just 14 years after the Lower Chenab Canal was constructed. Despite conclusions of a special Committee of Enquiry in 1847 at Karnal, India along the Western Jumna Canal, which had established that inadequate drainage would cause marsh fever or malaria along new irrigation canals, the same lessons had to be re-learned in the Punjab. These lessons were codified again in the 1932 report of the Waterlogging Board of Punjab. Proper alignment of canals away from areas where seepage would cause flooding, and well executed drainage works became a standard design component of all new canal systems, and it was added to existing systems wherever waterlogging and mosquito production was occurring. The Irrigation Department became the most important public health agency in the country.

Flooding

Overall surface drainage in the Faisalabad district is quite good. Most of the average floods drain out of the district quite nicely into the river Chenab on the west and river Rabi to the east and south. However this is not the case when there are heavy rains and flood waters from the north also enters into the area as flash floods. This happened once in Jaranwala Tehsil in 1958 and in all three tehsils of the district in 1973 floods. Faisalabad District did not suffer severely during the 1992.

As the drainage courses pass through the low lands, flood waters affect them the most. The immediate effect is reduced salts in the topsoil due to leaching of the affected area, thus improving productivity of the land due to improved water contents and reduced salts in the root zone. However the long term effect of these floods is a rise in the water table resulting in higher movements of salts upwards into the root zone. This double impact, namely shallow water tables and increased salt concentration results in reduced yields and productivity.

Had all the natural drainage channels been left unobstructed and open, these adverse effects might have been confined to lesser areas. As a result of obstructions, due to construction, cultivation of lands and building of houses, water spread into

the adjoining areas causing damage that otherwise would not have occurred.

Flooding also has adverse effects on the soil fertility due to leaching of nutrients out of the area and washing of nutrients and pesticides into the groundwater and the Chenab and Ravi Rivers. The groundwater also increased its salt load as percolating water recharged it with salts washed from the soil above.

Biodiversity

With population growth and development, biodiversity is under threat throughout Pakistan. Specifically in relation to water quantity issues, the main threat is to wetlands, specially mangroves, which face decimation owing to the existing and planned water withdrawals for irrigation. Inland fresh water bodies are also threatened by existing and planned dumping of saline effluent and agri-chemicals. Biodiversity in arable areas will suffer if plans for improving watercourse delivery and on-farm application efficiency are implemented without regard to wildlife habitat and maintaining organic processes in soils.

Corrective Measures Taken

Malaria

Unfortunately all the experience in malaria control by good canal design and adequate drainage was swept aside after the Second World War with the excitement caused by the use of DDT and chloroquine in malaria control operations in Sardinia and parts of South America. In 1960 a Pilot Study was initiated in Pakistan, and in 1961 a National Malaria Eradication Program was initiated in Punjab, including Faisalabad District. Malaria had again become a severe problem because of wide-spread waterlogging caused by the rise of the water-table to less than 3 feet from the surface in much of the area. The prevalence of malaria was about 15% (Positivity of blood slides, known as the SPR) prior to initiation of this Eradication Program. The Eradication Program covered all of Punjab by 1965 and produced a marked drop in prevalence. However the Programme collapsed by 1972 when the malaria mosquitos became resistant to DDT. An epidemic occurred throughout Pakistan with over 10 million cases, and a prevalence of 20%.

Instead of renewing drainage efforts to control malaria, the program was redesigned with another biocide, malathion, and the addition of a large component of treatment of infected persons with the synthetic drug chloroquine. This program was launched in 1975, and by 1977 it also collapsed due to resistance of the

mosquitos to the new biocide. This program was using a budget from USAID equal to one-third of the National Health Budget at the time it collapsed.

A third time the program was redesigned, but with less emphasis on biocide spraying of mosquitos and more emphasis on drug treatment of infected persons. Again no attention was paid to the need for drainage of mosquito habitats, or other environmental or behavioral prevention methods.

With the increased use of drugs for treatment, the malaria parasite began to develop resistance to chloroquine and in 1981 malaria again increased markedly in Faisalabad District. At present, in 1993, chloroquine is effective in only half the cases reporting to government centers for treatment. Other new drugs are too expensive for general use. Thus the program no longer has a significant impact on malaria transmission, except when extra efforts are made after heavy floods, such as those of 1992. In this case a lot of malathion was sprayed, and a lot of chloroquine was given out, with less than 50% effectiveness. For all practical purposes the Malaria Control Program, reorganized in 1977, is finished. No movement has been made towards environmental or behavioral methods of control, despite considerable urging by international health authorities.

Thus from 1900 to 1960, and from 1980 to the present, the history of malaria transmission in Faisalabad District was written by the water managers, not health officials. The only lasting effect of 12 years of heavy spraying with DDT and 8 years of sporadic spraying with malathion has been contamination of the environment with biocides, and little permanent improvement in health.

It is instructive to compare the temporary fluctuations in malaria prevalence due to the short biocide efforts of the Ministry of Health, with the longer trends in malaria transmission and management of water around Faisalabad. The time chart of water table level and malaria prevalence shows that increased waterlogging was followed by increased malaria, and that decreases in waterlogging had the opposite effect, at least until the water table was dropped well below the problem level of 3-5 feet. There was also probably a strong geographical correlation, not only in Faisalabad District but throughout Pakistan, between water-logging and malaria, as first recognized in 1847 in India.

In more recent years, especially since 1980, the geographical distribution of malaria transmission in Faisalabad District is probably more closely related to shallow tubewells, than to waterlogging. The shallow tubewells provide the farmer with sweet water throughout the year, and also provide the malaria mosquitos with favorable breeding conditions. When these

locations are within a kilometer or two of villages, malaria is transmitted year-round. Also when shallow handwells are used in villages to bring up the layer of sweet water at the top of the aquifer, the small seepage areas receiving the excess water from these handpumps become mosquito habitats. Usually these are very close to villages and sources of blood meals for the malaria mosquitos.

Diarrheal Diseases

The shortage of water for domestic purposes resulted in continued high rates of diarrheal disease in Faisalabad District and in high mortality rates of infants. The response was to develop additional wellfields for Faisalabad Municipal Corporation (FMC) near the Chenab River just below Chiniot on the Eastern bank, and pump the water to FMC, to be distributed after chlorination. This Phase I was completed in 1992, and Phase II is expected to start soon, by adding additional capacity to filter and chlorinate canal water taken from Rakh Canal.

Alternative Approaches

Malaria

A historical analysis showed that malaria was being controlled in Faisalabad District by the major water management programs, primarily the initial program of deep public tubewells. **If this had been recognized in the early 1960's and the $134 million from USAID for expenditures on biocides and drugs had been instead put into improved tubewells and better drainage, we would now have permanent measures for malaria control.** Instead Pakistan has the residue of biocides in the environment including malathion the major chemical used in malaria control, and the villages suffer a reduction in biodiversity due to large scale spraying operations of the Malaria Eradication Program. Although the malathion was sprayed inside homes and not in the water, the inevitable accidents along with the need to wash clothing, equipment and containers led to widespread dissemination of this and other compounds.

If a broader environmental approach to malaria control had been followed it is also likely that more attention would have been paid to the use of fish and other predators of mosquito larvae instead of chemical larvicides used in the FMC, and the recent use of bednets soaked in repellents. These environmentally and behaviorally oriented measures have been ignored however because of the technical orientation and training of the entire Malaria Program staff in the use of biocides and drugs. This orientation was widespread after the Second World War because of the scientific and commercial biases in favor of

miracle chemicals and drugs, the "silver bullets" of the Post-War Age, believed to be effective against all manner of demons.

Diarrheal Diseases

The best method to control diarrheal diseases is the provision of safe water to homes. If the rate of supply reaches 100 liters per person per day, diarrheal disease rates are markedly reduced because of the double impact of safe drinking water and adequate water for washing of hands, food and eating utensils. Thus expansion of the system in proportion to the population growth would have caused a major reduction in diarrheal disease and infant mortality. The proposed systems in the WASA 1993 Master Plan are certainly adequate to achieve this objective. However they appear unsustainable for energy considerations.

When crucial resources such as food and water are scarce and of fixed amount, it is irresponsible public policy to reduce infant mortality without parallel reduction in the birth rate. Acknowledging the difficulty of early attempts in population management, it is now clear that many positive measures such as improved education of women have the natural consequences of later marriage, increased spacing of children and thus lower fertility. **It would have been better to couple general education of women with the malaria and water programs, thus reducing the terrible population pressures caused by the improved public health.** In some industrialized countries, general education of women has also resulted in their assumption of leadership roles, both nationally and locally, in environmental protection and conservation.

5. CONCLUSIONS

The conclusions of this study are organized into the major concerns expressed in the Introduction: increased efficiency of water use; enhanced water quality; and improved water management. Conclusions related to each of these concerns tended to be based on strong themes found in the newly emerging philosophy of the sustainable environment. These themes include: the separation of resource streams; realisitic pricing for the use of resources; open and public planning for resource protection; and conservation of resources. We elaborate on these themes in the following paragraphs.

It is essential for donors and development planners to recognize that Pakistan is facing a water resource crisis because of rapid population growth. The time when water diversions, development of new land for farming, and tapping of new sources of hydroelectric energy could also expand rapidly is finished. Survival of future generations will require reductions in resource consumption and population, along with conservation and recovery of resources.

There has been a steady reduction in storage capacity of the main reservoirs of the Indus River system due to heavy sediment loads in the upper portions of the rivers. The storage losses are occurring primarily in Tarbela and Mangla Reservoirs. This reduction in storage will inevitably result in reduced regulation capability of reservoirs and, hence, decreased water availability for irrigation use in late kharif (September), and in rabi and early kharif ((April-June). The sustainability of many donor-funded water management programs, including the SCARPs, are also likely to be affected by the energy projections based on the change in the source of power generation from hydro-electric to thermal. **As electricity becomes more expensive, the cost of operating tubewells and most other pumping operations related to water supply and sewage disposal will increase significantly.**

Increasing Efficiency of Water Use

Water use efficiency is very low in the Faisalabad District. Almost one third of the water diverted from the Chenab River into the district's canals is lost through seepage, and leakage along the canals, distributaries and minors. Water is subsequently lost from watercourses due to their poor maintenance, and from the fields themselves due to misapplication of irrigation water.

Together, these losses result in about 35% rate of efficiency in the delivery of water to crops -- a very low return

per unit of water diverted for irrigation. **The experience of several donor projects that have made structural improvements to canals or have supported the lining of watercourses indicates that the most cost-effective water management measures -- the maintenance of large canals -- have been largely ignored.**

Sustainability implies adequate and continuous maintenance. Donors should support this simple and relatively inexpensive activity in the vast canal system of Punjab, rather than import complex machinery or install major infrastructure for which the government has limited resources to operate and maintain.

There are over 8,000 tubewells in Faisalabad District, most drawing water from shallow depths along perennial canals. The majority of these wells are privately owned. These tubewells have given farmers flexibility in their irrigation schedule for various crops by allowing them to apply groundwater water conjunctively with canal water. This conjunctive use has brought many farmers in the district close to what is called "irrigation on-demand". Installation of most of these tubewells was a private-sector response to unreliable or unpredictable public sector services. Donor support for better on-farm water management must tap this response and promote a greater partnership between public and private initiatives. Beneficiary investment in the management of water resources will ensure more effective and sustainable management than donor and government efforts alone.

Enhancement of Water Quality

A common theme in strategies to protect resources for use by future generations, and in improving the efficiency of resource recovery, is the separation of resource or waste streams. An initial step in this strategy is for water users to maintain these resource streams separate from the beginning. Once fresh and salt water streams are mixed, the cost of reclaiming the fresh water is enormous. Once toxic metals are added to domestic sewage, removal of the metals so that the sewage can be used for soil fertility is extremely expensive.

Faisalabad Municipal Corporation has repeated the mistake of most industrialized countries by combining domestic and industrial waste waters into drains and sewers originally dedicated solely to rainfall runoff. Combining these natural and urban flows makes recovery extremely expensive and often impossible, thus permanently damaging the ecosystem with toxic materials and preventing their use by generations to come. Mixing these wastes with storm waters increases the volume of wastewater, causes widespread contamination of the environment during floods, and also degrades aquatic habitats for long reaches downstream of the city during normal or dry seasons.

It would have been far better for the FMC to have maintained the flows separate from the very beginning. Domestic wastewaters without industrial contamination could be then applied immediately to agricultural land to sustain topsoil fertility and structure.

In terms of a program for the Pakistan's national and provincial EPAs, one should think first of determining the non-reusable toxic materials and banning their discharge immediately, working toward a goal in 5 or 10 years of zero discharge for all industrial wastes.

Donor-supported programs that have been established for the reclamation of waterlogged lands have also mixed the resource streams. As a result, these programs are proceeding in an unsustainable direction. The reclamation strategies of the early twentieth century, that of improved alignment of canals and improved drainage, was completely ignored by technical specialists who, in mid-century, proposed deep tubewells to lower water tables. The deep tubewells introduced in the SCARP programs have brought brackish water to the surface where it has mixed with the sweet water flows or deposited salt in the topsoil. Once mixed with salt, the sweet water was lost for future generations. Shallow tubewells were an improvement because they tapped the upper sweet water lenses and did not bring up salt to contaminate the surface. However the large majority of deep tubewells are still bringing up brackish water.

The underdrain system, such as that being installed by the Fourth Drainage Project, is perhaps the most sustainable approach to waterlogging and elimination of salts from topsoil. This approach offers the future hope of easy recycling of sweet drainage water, once sufficient salts are taken out of the upper soil profile by coordinated leaching programs. It is unfortunate that the under-drain program of the Fourth Drainage Project requires large energy expenditures to install the drains, and continued energy expenditures to pump the drainage water from the sumps back to the irrigation channels. The continuous requirement for pumping with electrical energy is sustainable only as long as electricity is cheap. Realistic pricing of electricity, and future shrinkage of the hydroelectric power supply will raise the true cost, and make the drainage option more expensive.

Thus a more environmentaly sustainable strategy to handle the waterlogging would have been continuation of the original corrections of the early twentieth century: better alignment of canals; promotion of better drainage; and, taking of low and inevitably poor quality land out of agricultural production and reserving it for other uses. Planting of crops that can utilize brackish water, and that draw down the water table would be the

intermediate step toward more sustainable soil reclamation.

Improvement of Water Management

The lack of a service orientation toward users, the lack of user involvement in decision making, and the lack of accountability of water sector agencies to users and the local electorate have all combined to foster a widespread alienation and distrust of civil authority among ordinary citizens. There is, therefore, no sense of ownership of the City's resources and problems among either its elites or its less privileged inhabitants, and little felt obligation to contribute towards the cost of managing the water resource in an efficient and sustainable manner. The result is a system that neither delivers service nor recovers its cost.

Building the legitimacy of the service delivery organizations is an essential first step in promoting environmentally sustainable use of water, and financially sustainable management systems. Without this level of institutional reform, sustainability will remain a development "buzzword" because neither resource conservation nor cost recovery is possible without popular participation.

Official agencies need to open up their processes of planning and decision-making to effectively engage local communities. Since an open process is often perceived in terms of loss of control by official agencies, donors should limit their investment and support to those agencies whose leadership is genuinely committed to popular participation.

Methods for selecting project officers and project areas are, therefore, the foremost aspects of institutional reform for interested donors. Only then can donors engage in a meaningful dialogue for policy change and reform with beneficiary institutions. Once these pre-requisites are fulfilled, donors and government agencies can pursue a number of important directions for policy and institutional reform to good effect.

A preliminary agenda for institutional reform of service delivery organizations must be an integral part of a local partnership initiatives. The Faisalabad case study suggests that the planning process followed by water sector agencies is, in essence, a capital budgeting exercise revolving around political decisions on the allocation of available funds to various, presumably influential constituencies, in aid of enhanced water supply. Aspects of service delivery, conservation, quality and other long-term concerns are omitted from what is currently understood as planning.

A more adequate approach to planning for water management in

both urban and rural areas would require each agency to prepare and implement the following: a zoning plan to facilitate the separation of wastewater; a phased service plan that has been discussed with the local community; a monitoring plan with environmental, financial and service indicators; a staffing plan for the above-mentioned requirements; a financial plan with all possible sources and applications; a public interest communication plan to engage the community in a continuing dialogue; and a strategic plan to give direction and coherence to all of the above.

The Faisalabad case study clearly points to the need for donors and the Government to support a stronger role and capacity for the Punjab EPA to monitor environmental quality and enforce standards across local jurisdictions. This support would be an important part of an environmental "sector" approach to donor assistance. The need for policy dialogue at the provincial level is also evident from the Faisalabad case. Foremost is the need to make local agencies accountable to local communities rather than the provincial government.

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ANNEX A

TERMS & ACRONYMS

AID	U.S. Agency for International Development
brackish	Water that contains more than 1000 ppm
DOFWM	Department of On-Farm Water Management
EUAD	Environment and Urban Affairs Division of the Ministry of Housing and urban Affairs, Pakistan
FDA	Faisalabad Development Authority
FMC	Faisalabad Municipal Corporation
IIMI	International Institute of Irrigation Management
IUCN	International Union for the Conservation of Nature
LCC	Lower Chenab Canal
LG&RD	Local Government and Rural Development Department
katchi abadi	Urban squatter settlements
mogha	Outlet from a minor or distributary canal
NCS	National Conservations Strategy
PEPA	Punjab Environmental Protection Agency
PHED	Public Health and Engineering Department
sweet	water that contains no more than 1000 ppm
UNCED	United Nations Conference on the Environment and Development
USAID	AID Mission, Pakistan
WAPDA	Water and Power Development Authority
warabandi	System of rotational water deliveries to farmers served by a single watercourse
WASA	Water and Sanitation Authority

ANNEXES

ANNEX B

Team Itinerary and Individuals Consulted

ISLAMABAD

Date	Individuals	Designation & Agency
April 20, 93	Mr. Asif Mahmood	Project Officer USAID
	Mr. Allah Jawaya	Environmental Engineer, UNDP/WORLD BANK
	Mr. Usman Qamar	Irrigation Engineer, WORLD BANK
	Mr. Hassan Tayyab	Project Officer ADB
April 21, 93	Dr. Tariq Banouri	Executive Director, Sustainable Development Policy Institute (SDPI)
	Dr. Abdul Jabbar	Research Fellow (SDPI)
April 22, 93.	Dr. Mohammad Jaffar	Professor of Chemistry, Quaid-e-Azam University
	Mr. Mohammad Saleem	Senior Scientific Officer, National Institute of Health
	Mr. Ingo Guhr	Chief Water & Sanitation, UNICEF
	Dr. John Swanson	Deputy Chief ARD, USAID
	Mr. Muzzamal Qureshi	Chief Water Resources Hussain Engineer, USAID
	Mr. Ch. Laiq Ali	Mission Environmental Engineer, USAID
	Mr. Asif Mahmood	Project Officer, USAID

LAHORE

April 24, 93.	Mr. Mushtaq Ahmed Gill	Director General, On Farm Water Management Directorate
April 25, 93.	Qazi M. Anwar	Deputy Secretary, Punjab Irrigation & Power Department

	Mr. Mazhar Ali	Punjab Irrigation & Power Department
	Mr. Miraj-ud-Din Nagi.	Director General, Punjab Environmental Protection Agency (EPA)
	Mr. Yousaf Saleem	Deputy Director, EPA
	Mr. Shams-ul-Mulk	Member Water, Water & Power Development Authority (WAPDA)
	Mr. Iftekhar Khan	Director General, Water & Sanitation Authority (WASA), Lahore
	Dr. Senen M. Miranda	Senior Irrigation Specialist, International Irrigation Management Institute
	Mr. Marcel Kuper	Associate Expert, (IIMI)
	Mr. M. Saleem Mulk	Social Scientist, (IIMI)
	Mr. Saeed ur Rehman	Economist, (IIMI)
	Dr. Bagh Ali Shahid	Principal Irrigation Engineer, (IIMI)
	Dr. Imtiaz Shah	Director, Institute of Malaria
April 26, 93.	Mr. Zahid Saeed Khan.	Regional Coordinator, (CWMP) USAID
	Mr. Mohammad Aslam	Deputy Director, M&E WAPDA

FAISALABAD.

April 27, 93.	Syed Akhter Ali Shah	Superintending Engineer, LCC West, Punjab Irrigation Department
	Mr. Zahid Saeed Khan	Regional Coordinator, CWMP USAID
April 28, 93.	Mr. Mohammad Nasim	Assistant Director, EPA
	Ch. Mohammad Akram	Deputy Director, EPA
	Dr. Abdul Rashid	Agricultural Chemist-I, AARI

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	Dr. Mohammad Ibrahim Jalees	Agricultural Chemist-II, AARI
	Mr. Mohammad Siddique Hamdard	Soil Chemist, Plant Protection Institute
	Dr. Abdul Ghafoor	Associate Professor, University of Agriculture
	Dr. Abdul Rauf	Associate Professor, University of Agriculture
	Mr. Mohammad Saddique Chaudhry	Director General, WASA Faisalabad
	Mr. Faisal Munir	Commercial Diseases Officer, District Health Office
	Mr. Mushtaq Ahmed	Malaria Officer, District Health Office
April 29, 93.	Ch. Abdul Haque	Deputy Chief Engineer, Forth Drainage Project, WAPDA
May 2, 93.	Dr. Shah Mohammad	Professor (Retd) University of Agriculture, Faisalabad
	Malik Dost Mohammad	Director General, AARI
	Dr. Fazil Aqil	Deputy Director, AARI
	Mr. Abdul Ghafoor Kauser	Deputy Director, AARI
	Mr. Liaqat Randhawa	Director Environment Control, FDA: Project Director, ODA-assisted FAUP
	Mr. Khadim Hussain	Deputy Director, Planning & Design, WASA, Faisalabad
	Mr. Saleem Akhter	Deputy Director Revenue, WASA, Faisalabad
	Mr. Mohammad Munir	Deputy Director Finance, WASA, Faisalabad
May 3, 93.	Ch. Mohammad Sharif	Coordinator, On Farm Water Management Directorate, Faisalabad

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	Ch. Ali Ahmed Dogar	Soil Fertility Officer, AARI
	Dr. Muhammad Mukhtar	Deputy Soil Fertility Officer, AARI, Faisalabad
	Mr. Mohammad Aslam Adil	Agricultural Officer, Agricultural Extension, Faisalabad
	Mian Mohammad Amin	Superintending Engineer, Public Health and Engineering Department
	Mr. David Ryman	CTA, ODA-assisted FAUP
May 4, 93.	Mr. Masud ul Hassan Shah	Sub-Divisional Officer, Public Health and Engineering Department

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ANNEX C

Management Responsibilities of Various Agencies in the Water Sector in Faisalabad District

Urban (Faisalabad City)

Water Supply	- WASA, except for: - Industrial consumption which is met from tubewells installed and operated by industrial units themselves; - The informal sector - poor workers who sell water to the City in bottles and large cans; and, - The katchi abadis accounting for one-fifth of the City's population, which are not served by WASA since they are considered illegal, but may be served by the informal sector.
Sewerage	- Open street sewers - FMC - Other sewerage - WASA
Drainage	- Up to and including sulludge channels: WASA - Main disposal drains: PID

Rural Faisalabad District

Domestic Water Supply	- Large schemes: PHED; scheme identification may involve elected Members of the Provincial Assembly - Small community schemes: LG&RD, with the cooperation of local communities; scheme identification is by the elected District Council - Households with their own dugwells, Persian Wheels, tubewells, etc.
Wastewater Disposal	- Farm-households/communities
Irrigation	- Up to and including the mogha: PID - Watercourse (below mogha): farmers - Large civil works may involve WAPDA - Watercourse civil works: DOFWM with the cooperation of farmers
Drainage	- PID - Large civil works may involve WAPDA

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Environmental Issues	- From FDA: the Director (Environment Control) of FDA. - From the Punjab EPA: its Deputy Director based in Faisalabad.

The following financial flows characterize the system outlined above:

Urban (Faisalabad City)

Water Supply	- WASA recovers a fraction (**% during 1992-93) of its O&M costs from its customers; **% from its share in the property tax receipts for the City; and most of the rest is received as a non-development loan from the Provincial Government, which will be written off. - WASA pays the PID about Rs 300,000 per year for drawing water from an irrigation canal (the Rakh Branch of the Lower Chenab Canal system). - The industrialists tap the aquifer directly. From 1992-93 they are expected to pay an aquifer charge to WASA. - Consumers pay the informal sector for water purchased in cans and bottles. - Capital investments with donor assistance.
Sewerage	- WASA imposes a sewerage charge on the City's inhabitants; subsidized by the Provincial Government - Not clear whether FMC imposes a separate charge - Capital investments with donor assistance
Drainage	- WASA imposes a sewerage charge on the City's inhabitants - PID is paid by the Provincial Government; not clear whether it is paid by the City for O&M of the main drains

Rural Faisalabad District

Domestic Water Supply	- PHED is paid by the Provincial Government and assisted by the donors. - LG&RD is paid jointly by the Provincial Government and District Council - Local communities often contribute

	labor and local material
Wastewater Disposal	- Farm-households/communities manage their own costs
Irrigation	- PID recovers part of its O&M costs from farmers; the remainder is subsidized by the Provincial Government. - Farmers maintain the watercourses and contribute labor for watercourse improvement - WAPDA raises money for capital investments from donors - DOFWM raises money for capital investments from donors
Drainage	- PID recovers part of its O&M expenditure from drainage cess imposed on farmers, the balance from the Provincial Government - WAPDA and PID undertake capital investments with donor assistance
<u>Environmental Issues</u>	- FDA raises its revenues from a variety of local and Provincial sources (the latter being more important) - Punjab EPA is funded by the Provincial Government