INTERNATIONAL IRRIGATION MANAGEMENT INSTITUTE

REVIEW

Vol. 5 No. 1 July 1991

Decision Decade
for Pakistan's Irrigators

Key Topical Issues and Trends in Irrigation Set Out
as the Year 2000 Approaches

Nontechnical Survey of the Irrigation Situation
and IIMI's Role in it

WATERSHED TÊTE-À-TÊTE IN ROME

IIMI Review invited C. Hollis Murray, Assistant Director-General of the Forestry Department, Food and Agriculture Organization, and Asit K. Biswas, President of the International Water Resources Association, to record a discussion on watershed management when they met in Rome recently.

The development of irrigated agriculture often leads to far-reaching changes in the ecosystem, some of which threaten the long-term productivity of the resource base. For example, soil deterioration can lead to large amounts of irrigated land going out of production; detrimental changes in water quality downstream from irrigation projects can reduce the utility of such water to other users; and irrigation can induce large increases in water-related diseases, such as malaria and schistosomiasis. It is now generally agreed that irrigation involves complex environmental and social interactions which must be taken into account in the planning, design and management of irrigation projects if adverse environmental effects are to be mitigated or eliminated.

Biswas: Two major resource management issues that are now firmly in any international agenda for the 1990s are the steps that should be taken to reduce the rate of deforestation and how to manage optimally limited available water resources, especially in arid and semiarid developing countries.

Murray: There is no question that forest and water resources are going to be two of the most pressing issues of the present decade. If we look back and review the experience over the past 2-3 years, nearly every week one would find a story in a major newspaper or magazine that dealt with forests and/or water. I am convinced that management of both these natural resources will continue to be the priority issues of the nineties. Considering their importance for the long-term development of nations, and thus to human welfare, there is simply no other option. With continual increase in the world population, and efforts to improve the quality of life of each of the world's citizens, resources like forests and water, though they are renewable, are being overexploited on an ever-increasing scale. Fortunately, in nearly all countries, people and decision makers alike are becoming more and more convinced that these resources must be managed in a sustainable manner for their own benefit and that of their children and grandchildren.

Asit Biswas (on left) with C. Hollis Murray.

Biswas: Forest and water management are, of course, closely interlinked. For example, poor forest management has adverse impacts on water conservation and development and vice versa. We now have many examples from different parts of the world where deforestation in the upper catchments of watersheds has had negative impacts downstream.

Murray: That's absolutely correct. Deforestation is responsible for many environmental problems related to water scarcity: groundwater level decreased, springs and wells dried out, water quality affected. Deforestation upstream contributes to higher intensity and frequency of floods in the plains downstream. Furthermore, deforestation is accelerating the rate of soil erosion which in turn creates additional problems for irrigation projects. This has three serious implications. First, the loss of topsoil results in declining agricultural production in the highlands. Second, eroded soil gets deposited in reservoirs, thus reducing their water storage capacity and economic lives, as happens in many irrigation projects all over Asia, Africa and Latin America. Thus, the cost-effectiveness of irrigation projects starts to decline and irrigated areas become limited. Third, sedimentation from wind and water erosion also occurs in river channels and irrigation canals, which means more frequent maintenance resulting in increased cost of operating and maintaining irrigation projects.

Biswas: All we have discussed so far clearly indicates the importance of land, water and forest management on an integrated basis. Clearly, management of one resource, without consideration of the other two, is unlikely to produce optimal results.

Watersheds could be often considered as discrete geographical units within which management of land, water and forests can be rationally integrated. Can you

(Continued on page 4)

Letters to the Editor,

I write with reference to the review of problems of Indian irrigation adverted to in IIMI Review Vol 4. No.1. While I compliment the IIMI Review Editor for the review, I carry a feeling that to some extent the review appears skewed in that it presents views of largely those who did not have an opportunity to handle the policies and problems of irrigation in the four States visited.

In his review the Editor has quoted observations of Mr Kathpalia, presently a Consultant with Ford Foundation; Dr Sakthivadivel, former Director, Water Resource Centre (WRC) Anna University; Dr. Yoganarasinham, Director WRDTC; D.T. Prasad of Patna University; Dr Tushar Shah, an economist; Dr. Arora, Consultant, USAID and also Dr. Swaminathan, Dr. Chambers and Dr. Seckler. None of them handled State Irrigation Policy. Since the Editor has not quoted any of the State Irrigation Policymakers I presume he has not met them. I am emphasizing this because Irrigation is a State subject and even the Government of India can play only a limited role in influencing State policies in this regard. The Review would have presented a better picture if discussions with senior State-level officers and their views were included.

I am inclined to agree that as at present, with a food production of 150-170 million tons for the last 2-3 years, the issue at present may be "not a shortage of food," (p.3). But with a population increasing at the rate of 15/20 millions per year, there is a real apprehension that the 'Second Malthusian race' may be a reality. This is more so, considering that the Indian monsoon is erratic. Should a real bad monsoon visit India (God-forbid), the production of food grains would fall to 100-120 million tons, woefully inadequate even for the present population. In the past, production from irrigated areas has helped India to tide over such situations. With about one third the area of the country being drought-prone where agriculture remains a gamble to a certain extent, there is need to extend irrigation facility horizontally. Drought proofing of drought-prone areas will, thus, continue to be one of the major objectives of WRD (Water Resources Development) effort. This does not mean vertical extension (better use of irrigation from irrigation facility already created for increasing production) should be neglected. The need is for a two-pronged attack simultaneously, or rather a three-pronged attack to include groundwater exploitation if the Malthusian race is to be won.

M.G. Padhye
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Former Secretary of Irrigation,
(1982-85) Government of India.

Changes in IIMI's Board

Mr. David Bell, Chairman of IIMI's Board of Governors since January 1988, will retire at the end of this year at the completion of his term on the Board. Dr. M.S. Swaminathan will become the new Chairman of IIMI's Board on 1 January 1992.

David Bell served as Director of the US Budget Bureau and as Administrator of the US Agency for International Development (USAID) during the Kennedy and Johnson administrations, before joining the Ford Foundation as Vice-President for International Activities. While at the Ford Foundation, Bell played a major role in the formation and development of the Consultative Group on International Agricultural Research (CGIAR).

Dr. M.S. Swaminathan, Chairman-elect of the IIMI Board of Governors, is one of the world's most eminent agricultural scientists and a leader in environmental conservation. The former Director General of the International Rice Research Institute, Swaminathan was recently awarded the 1991 Tyler Prize for Environmental Achievement in recognition of his single-minded devotion to breeding genetically superior strains of wheat, rice and coarse grains which has contributed to higher grain productivity in India and other parts of the Third World. In his capacity as President of the International Union for the Conservation of Nature and Natural Resources (IUCN), Swaminathan has been instrumental in advancing food and nutrition security in the Third World.

CONTENTS

Director General: Roberto Lenton
Consultant Editor: Robert Lamb
Photo Credits: FAO: 2; E.J. Vander Velde: 5, 16, 29 bottom, 33 bottom; John Colmey: 7, 35; K. Hussain: 9; USAID: 10, 14, 15, 27, 29 top, 31 bottom; PAD: 18, 28, 31 top, 33 top, 36; Jacob Kijne: 8
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Satellite image of the Indus Basin north of Guddu Barrage. Photo: SUPARCO

(Continued from page 2)

briefly elaborate on FAO's role and philosophy in watershed management?

Murray: The Forestry Department of FAO has long been active in integrated watershed management with the objectives of protecting the natural resource base and improving the living conditions of the local people. This Department has been conscious, for a considerable period of time, of the importance of this approach, which is regarded as fundamental if the resources in watersheds are to be utilized on a sustainable basis for the benefit of the people living within the area. In cooperation with governments and national institutions in the planning and execution of watershed projects, we had always sought to emphasize these principles well before the concept of sustainable development became as widely understood and accepted as in recent years. The long-term sustainability of any watershed development clearly depends on sound management of its natural resources as land, water and forest.

Biswas: How extensive has your work been in watershed management?

Murray: Over a period of years we have cooperated in some 60 projects on various aspects of watershed management in many countries. Currently, some 27 projects are being executed in forestry which deal, in whole or part, with watersheds. Several new projects both national and regional in scope are also under active consideration for possible implementation.

Biswas: During the course of my work as an adviser on resources management, one common problem in nearly all developing countries was the lack of an adequate number of properly trained people who could plan, develop, and manage watersheds. Human resources development has to be a priority consideration for sustainable watershed development in developing countries.

Murray: I agree with you fully on the importance of human resources development. Trained people are the motor of economic development. Thus, my Department has always made serious efforts to train people in a variety of ways. For example, we have conducted several training courses on different aspects of watershed management. We have recently conducted four such courses on comprehensive watershed management financed by the Finnish International Development Agency.

We have prepared many manuals of Guidelines which could be used for training as well as for operational purposes in developing countries. In cooperation with the International Centre for Integrated Mountain Development (ICIMOD) in Kathmandu, Nepal, we have also organized awareness-raising courses on watershed management.

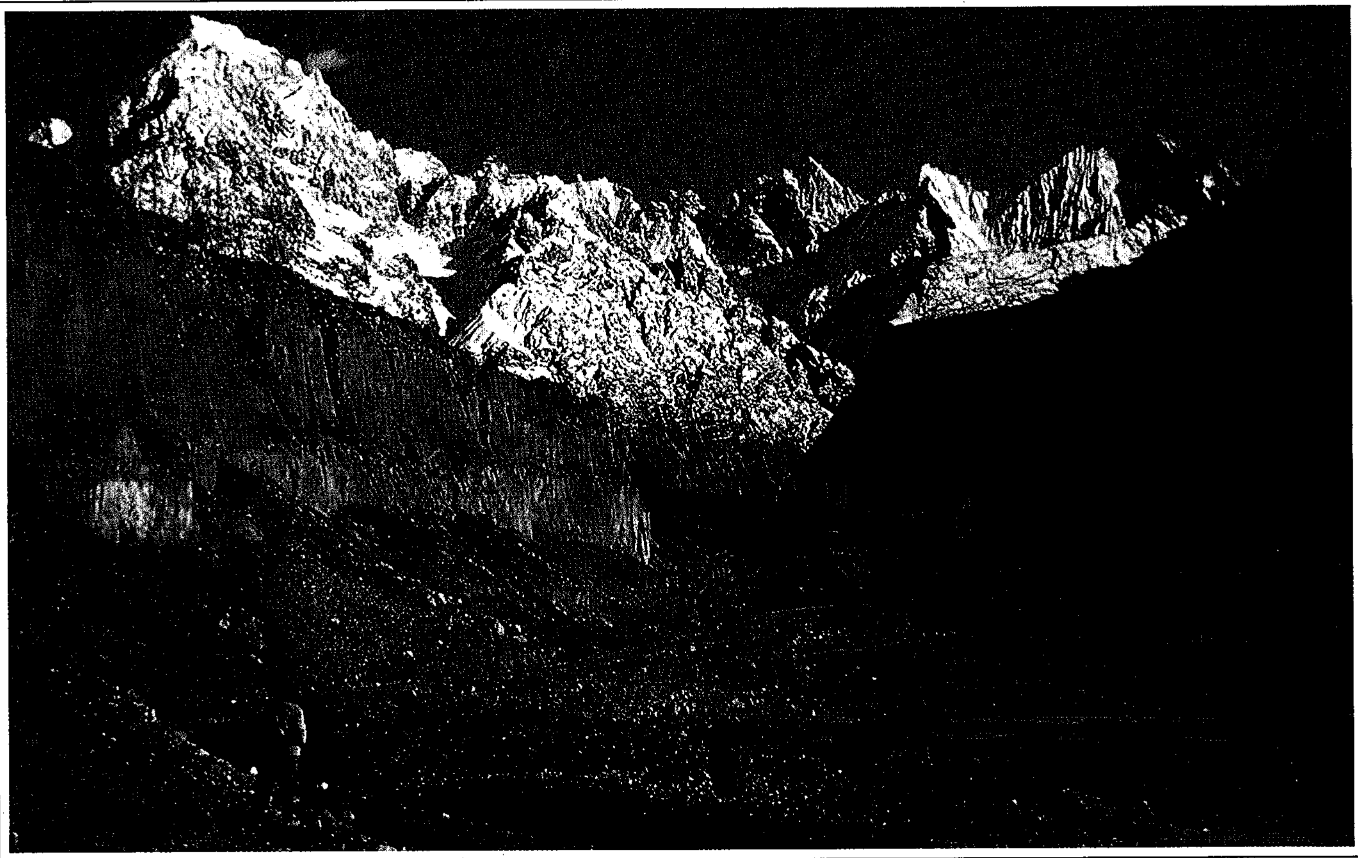
Moreover, almost all field projects in watershed management have catered for in-service training and have supported seminars at different levels for national experts, technicians and skilled laborers. Special attention has been given to women's involvement in watershed management activities.

Dissemination of information and transfer of knowledge and technology are also important considerations. Towards this end, we have established networks in the Caribbean for the English-speaking countries and in Latin America, for the Spanish-speaking countries. These are important mechanisms for the transfer and exchange of knowledge and experience between developing countries.

The FAO Working Party on the Management of Mountain watersheds has functioned for many years in Europe. The 17th session was held in Italy, recently and was attended by observers from developing countries.

Biswas: What in your view is an important characteristic which contributes significantly to the success of watershed management projects. FAO has successfully carried out many such projects. What would you say is the common thread that could make a project successful or a failure?

Murray: Probably the most important characteristic is the necessity of participation and involvement of local communities during the planning, implementation and operation of projects. You will probably recall that the World Conference on Agrarian Reform and Rural development (WCARRD), which was held in FAO in 1979 and which you attended, stressed the importance of community participation in rural development projects. There is no question in my mind that if projects in general, and those on watershed management in particular, are to fulfill their objectives, community participation needs more emphasis than had generally been given earlier. For example, for our current projects in Thailand, Indonesia and Jamaica, community involvement is built in right from the earliest phase. People's participation is also a basic principle underlying the Tropical Forestry Action Plan (TFAP), which was prepared by FAO, the World Bank, UNDP and the World Resources Institute.



*Traditional **kuhl** mountain channel, Gilgit. Pakistan's mountains hold the world's biggest stores of snow and ice outside polar regions.*

Managing Indus Water — A Whole Basin Approach

by S.S. Kirmani

Pakistan is blessed with rich water resources. The great Himalayan ranges dominate the weather, trap the monsoons and regulate the water cycle. The Himalayan watershed of the Indus and its tributaries includes the biggest glaciers outside polar regions and 44 of the world's 100 highest mountains.

Surveys of the 56-km Baltoro Glacier in the Shyok valley, have indicated it may store 120 billion cubic meters of water. Other large and small glaciers and icefields may hold more than 1,200 billion cubic meters. The major dam basins of Tarbela and Mangla are miniscule by comparison at a capacity of 18 billion cubic meters.

Porous rock and gravel formations that have accumulated where the river and its tributaries dissect the lower Himalayan and Siwalik ranges, store part of the monsoon rainfall for a time and feed the streams and rivers in the dry season. The capacity of this natural reservoir once amounted to more than 12 billion cubic meters but deforestation has reduced it, increasing flood and sedimentation hazards downstream. Watershed management to restore storage capacity has produced encouraging results in the Mangla Reservoir catchment.

The vast Indus Plains are underlain by sandy alluvium to depths of up to 300 meters and form a huge and highly transmissive aquifer system with a usable storage volume of free water much greater than all the existing and potential storage reservoirs on the Indus and its tributaries. Annual recharge to this groundwater reservoir is more than 56 billion cubic meters, of which some 45 billion cubic meters are usable. Although extensive development has taken place, there is potential for nearly 10 billion cubic meters extra abstraction without overdrawing. However, effective management is essential to maintain water quality on a sustainable basis.

Wide alluvial river channels in the Indus Plains (combined length 3,500-km) also serve as natural reservoirs and flow regulators. During high river stages, channels are filled, flood peaks are moderated and water seeps into the banks. When the river drops, channel storage is released and water stored in the banks seeps out as return flows. Releases from channel storage (3.5 billion cubic meters) take place throughout the *rabi* growing season (roughly mid-October to mid-April in Punjab, earlier in Sindh Province). Timing and quality of these releases are determined by man-made interventions in the rivers and storage reservoirs. Effective management to prevent deterioration is essential to husband gains from this natural storage.

It is time our engineers learned more about these immense water resources and natural reservoirs. Managed comprehensively, they will provide more water for productive use than many seem to imagine.

Pakistan ranks fifth in the world and third among developing countries in size of irrigated area. Around 25 percent of its territory is currently cultivated, 20 percent under irrigation.

International Food Policy Research Institute studies suggest Pakistan and Thailand are the only two countries in Asia that could export food on a sustainable basis in the next century. The studies emphasize, however, that the key to realizing this potential lies in improving current water and farm management practices, and agricultural inputs and services.

Agriculture is the livelihood of over 50 percent of Pakistan's 110 million population and is the most productive sector of the economy. From 1962 to 1982, agricultural production grew at an average annual rate of 4 percent, varying from 6 percent in the 1960s to 2 percent in the early 1970s. During the Sixth Five Year Plan (1984-88), average growth increased by 4 percent, owing largely to an increase of 10 percent in the production of cotton.

Though agricultural production increased dramatically in the "Green Revolution" years of the sixties, Pakistan was unable to sustain growth and is currently struggling to achieve self-sufficiency in food. Edible oil imports are skyrocketing. Against the targeted growth rates of 4.45 percent for wheat and 4.07 percent for rice of the Sixth Five Year Plan, achievements were 0.43 percent and minus 1.19 percent, respectively. Except for cotton, growth rates of all crops have stuck among the lowest in developing countries.

Between 1977 and 1988, irrigated wheat yields increased at an annual growth rate of 1.9 percent and IRRI rice at 0.9 percent, but World Bank data reveal that growth between 1984-88 stagnated, despite significant increases in farmgate water supplies (23%) and irrigated area (14%).

> World Bank Director, East Asia Pacific Division and Irrigation Expert Dr. S.S. Kirmani was formerly Director of the Indus Basin Project of Pakistan's Water and Power Development Authority. This article is based on extracts from Dr. Kirmani's Working Paper on Management and Policy Issues addressed to the Water Sector Investment Planning Consultative Meeting held in Islamabad, 12-14 March 1991.

At the heart of disputes over water apportionment lay a fear that there would not be enough water in the rivers to meet future needs. Such fears were justified when canal withdrawals were based on run-of-the-river supplies and crops were doomed if the system ran dry.

Today, however, surface water and groundwater storage reservoirs and inter-river link canals provide means to match water supplies closely to crop needs.

Past disputes caused an annual economic loss of almost a billion rupees. Benefits forgone were greater still. An increase of one to three percent of water supply to offset a shortage in critical months would have given a dramatic boost to crop yields.

Pakistan has more land than water and the ultimate constraint on future growth will be water, not land. However, Pakistan has more water and more irrigation than most countries and it has a great deal more of both than it is using efficiently and productively.

Pakistan is threatened by unsustainable withdrawals from surface water and groundwater resources alike. The quality of groundwater is deteriorating due to the lack of adequate arrangements for disposal of saline effluent. The cost of new water development projects is increasing and problems will continue to multiply if the practice of managing the basin's resources as separate and unrelated parts continues.

The Indus Basin is a single hydrological unit. Its surface water and groundwater resources are interrelated and constitute a single system.

If the saline water from the basin is not disposed of to the sea, it can adversely affect the quality of its useful groundwater resources. If dumped in the rivers, it would affect the quality of the river supplies. And if adequate fresh water is not released below Kotri, salt intrusion from the sea would affect the environment of the Indus Delta.

Any action that disturbs the natural conditions of the surface water and groundwater resources in one part of the basin has an impact on the rest. Integrated, comprehensive management (ICM) of the basin's resources is essential to optimize positive impacts and reduce negative effects to an acceptable level.

Although ICM of "water resources" and water management are terms that are sometimes used interchangeably, there are differences. ICM is designed to ensure efficient, equitable and productive use of water resources basin-wide and to provide adequate quantities of good quality water to all competing users at a decent cost. It addresses such issues as adequacy of hydrological data, watershed management, resource planning techniques, water use policies and practices, operations and maintenance, environmental protection, research and technology, water pricing and cost recovery.

There are compelling reasons why ICM of water resources must be the way forward for Pakistan. We have the largest single contiguous irrigation system in the world, its resources are remarkably diverse, the environmental problems are formidable and the economy depends largely on irrigated farming.

ICM is not new. The Punjab was the locale where it was conceived and first practiced. The Triple Canal Project of the early 1900s, the Haveli Canal of 1935 and the Link Canals of the Indus Basin Project in the late 1950s were highly effective measures toward integrated management of irrigation water to boost productivity on a grand scale.

But this vision has given way to disputes and a race to establish water rights through increased canal withdrawals by Provincial Irrigation Departments.

Mangla and Tarbela are operated as separate and unrelated reservoirs instead of the twin engines of crop and power production they were meant to be. The Jhelum-Chenab and Indus zones are run as independent hydrological systems. Groundwater resources have been developed extensively during the past 25 years,

Pakistan's farmers use and trade tubewell water to gain flexibility which canal supplies too often limit.

but canals are being operated as if groundwater does not exist.

Farmers are wiser. They use canal water and groundwater conjunctively to bolster crop yields and sell water to neighbors who do not have tubewells. However, the scope of such conjunctive use is limited and the potential for extending it system-wide has not been realized.

Water surplus in canal systems in one province could be shared with others at an agreed price. Or water accounts could be kept so transactions are balanced over time, especially in dry years when river supplies are short and mining of groundwater for short periods is feasible.

A growing body of scientists is warning of imminent climatic changes due to buildup of carbon dioxide and other greenhouse gases in the atmosphere. Like a one-way filter, greenhouse gases allow the sun's energy to pass through the atmosphere but trap reflected heat energy. Though the effect is not fully understood, it could have a major hydrological impact on the melting of high mountain snowpeaks and may result in seasonal changes in runoff.

If worldwide climatic changes occur as predicted, new management approaches may be necessary to keep water flowing in the Indus Basin.

Pakistan cannot afford to delay the integrated comprehensive management of the Indus Basin's resources which should be declared a priority objective of water policy. Establishing — and implementing— this policy will require commitment and courage. Success must lie in reorienting the focus of water sector institutions from water to crops and from exclusive concern for water rights to concern for optimizing production without losing water rights. Implementing ICM policies also means enhancing the capacity and capabilities of water sector institutions to address management issues confidently and well.

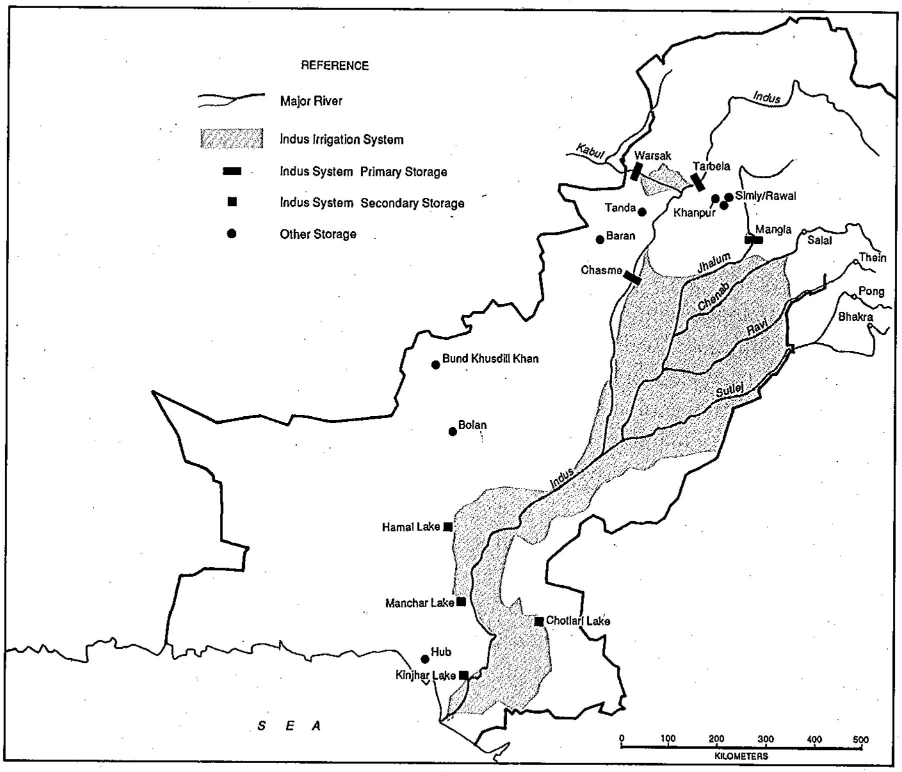
GIANT AMONG SYSTEMS

The irrigated area of the Indus Basin frames one of the largest contiguous irrigation systems (and one of the largest engineered artifacts) in the world, covering more than 16 million hectares and crossing nine agroclimatic zones. There are 3 major storage reservoirs, including possibly the world's biggest earth-filled dam (Tarbela), 19 barrages, 12 inter-river link canals, 59,500 kilometers of canals and about two million kilometers of watercourses and field channels.

Major canal command areas number 43, *chaks* (watercourse commands) 95,000 and there are 16,000 kilometers of surface drains. In addition, the irrigation infrastructure includes 12,500 large public tubewells, over 250,000 small tubewells and nearly 16,000 kilometers of surface drains.

Pakistan's total land area is 793,000 square kilometers, of which 192,000 are cultivated. Punjab has the largest cultivated area (122,500 square kilometers), followed by Sindh (37,000), North-West Frontier Province (17,000) and Baluchistan (16,000 square kilometers).

According to recent Water and Power Development Authority (WAPDA) and World Bank figures, ongoing federally funded works of extension, improvement or construction of canals and drainage or reclamation schemes in Pakistan could, if they perform up to expectations, provide around 60 percent of the incremental growth in production capacity required to keep up with the demographic growth rate and growing food demand — about 2.7 percent a year, or virtually a doubling of present food production over the next ten years. The 1.5 percent deficit will have to be made up by increases in irrigated area, strategic use of groundwater and other means requiring new management approaches.



Indus Irrigation System and Surface Storage.

Farmers install a turnout as part of watercourse improvement efforts by a Water Users' Association.

A PLAN FOR ALL SEASONS

by Khalid Mohtadullah

Pakistan's recently published Water Sector Investment Planning Study (WSIPS), steered by the World Bank and backed by UNDP, has proposed specific ways and means to upgrade the nation's water sector planning capacity. Improved criteria and procedures for screening water sector projects have also been proposed and both elements supply the context for a medium-term (1990-2000) investment plan for the sector.

The resulting plan is intended to be the first in a series of rolling plans that will be developed at intervals, in step with Pakistan's evolving circumstances and priorities. An important spinoff of the study has been the development of a computer-assisted methodology which federal and provincial planning institutions can conveniently use to update and refine the Plan at routine intervals. Control of the computer model used in this work, the Indus Basin Model Revised, was transferred at the end of the study to the Water and Power Development Authority (WAPDA) and key users in the provinces.

The authors of the study identified constraints that can crucially undermine water sector investments. A searching evaluation was made of the capacity of existing water sector planning institutions, at federal and provincial levels, to overcome these constraints. A new infrastructure of Provincial Planning Cells (PPCs) was developed with a view to rationalizing water sector investment programs countrywide. Both PPCs and WAPDA were provided with data processing technology and staff training appropriate to the enhanced planning task.

This article examines the main findings of the study regarding investment performance over the past decade, future targets in relation to imperative growth needs, constraints on water sector development planning and proposed corrective measures that will be put to practical test as the measures proposed in the WSIP study unroll.

Pakistan's water sector investment track record presents a mixed picture of achievements. The 1979 Revised Action Plan (RAP) for Irrigated Agriculture proposed a strategy of maximizing growth through investment in private tubewells, watercourse improvements, soil reclamation and improved utilization of irrigation systems, to be followed by major investment to boost existing assets.

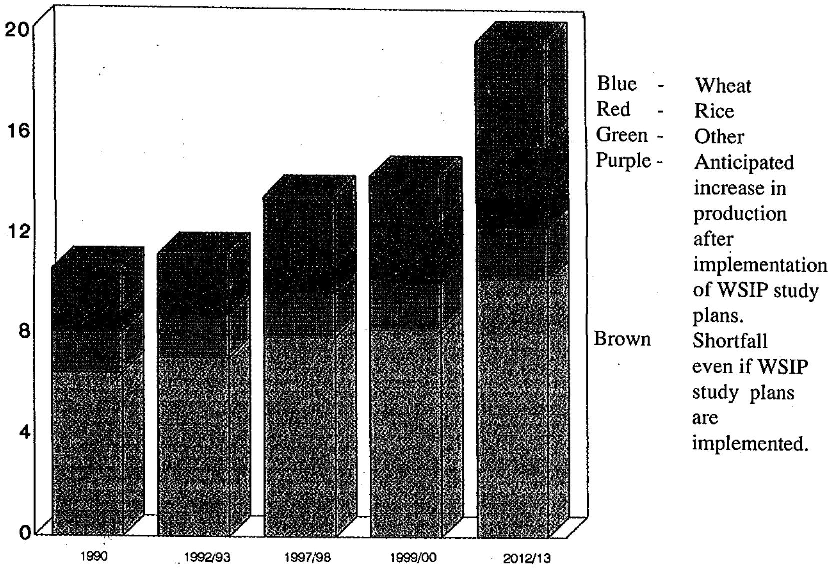
In fact, overall investment in the water sector under the national Sixth Five Year Plan (1983-1988) was 17 percent below RAP recommendations. The RAP recommended priority attention be given to investments of short gestation offering high returns but the recommendations could not be put into effect because of the continuing dominance of large drainage and canal extension projects.

No action was taken on the RAP recommendations aimed at bringing together institutions concerned with water and agriculture; progress in this direction has consequently been very limited. The underlying objectives nonetheless have many supporters and may yet be realized in particular provinces.

With the deferment of new storage facilities and the continuation of massive subsidies for inefficient projects, the need for better management and financial policies is every bit as great as it was when RAP was formulated. The undoubted success of private tubewell development gives new reason to accelerate the ongoing privatization of public tubewell facilities and redirect public subsidy for on-farm water management to areas of saline groundwater, while all programs need to put more emphasis on cost-effective management.

Mr A. R. Mahsud, Secretary of Pakistan's Ministry of Water and Power, presents a set of the WSIP study volumes to Senator Sartaj Aziz, Minister of Finance and Economic Affairs, at the Islamabad Consultative Meeting.

Future agricultural production will have to be stepped up sharply if it is to keep pace with an expected jump in population levels from 107 million (1987) to 148 million by the year 2000, or 207 million by AD 2013. Although yields of most crops have risen over the past 10 years, average annual growth has dropped mostly below 2 percent and it is doubtful if yield increases above 1.5 percent a year could be sustained in the future. With the investments foreseen in the WSIP study, an expected shortfall of 24 percent by AD 2000 could be cut to 10 percent. A still greater (36%) deficit by AD 2013 could be forestalled only by an annual 4 percent increase in average yields or net cropped area: neither target could be achieved without significant investments in improved irrigation water deliveries and protection from waterlogging, salinity and flooding.

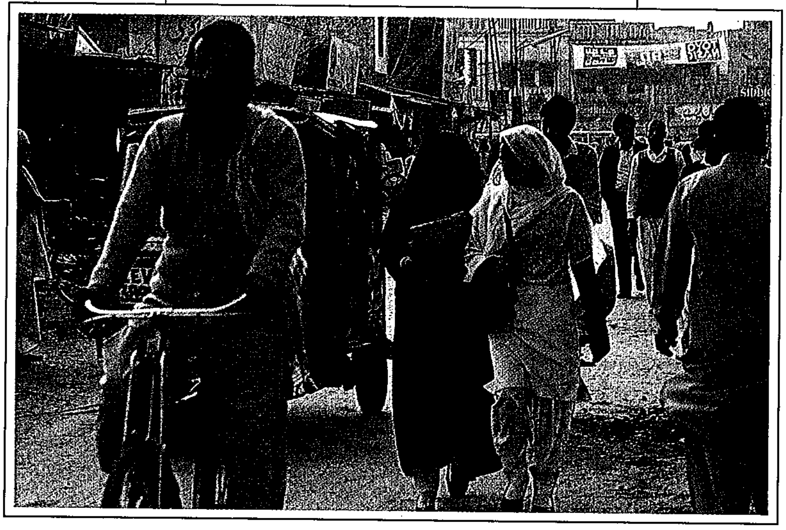


Note: Present total grain production = Blue + Red + Green
Anticipated production with WSIP study plans implemented = Blue + Red + Green + Purple
Shortfall if WSIP study plans are not implemented = Brown + Purple
Target production to feed nation = Total height of column

Present and anticipated grain production, Pakistan.

Constraints identified and taken into account in the WSIP study can be grouped under three categories — physical, institutional and financial constraints. Water availability remains foremost among the physical constraints. The system as a whole is short of water and irrigation is based on distribution of the supply over the largest area that can feasibly be watered.

Cropping intensities are therefore low but not, however, as low as might be expected because farmers throughout the basin have found a way to maximize production by partially irrigating a larger area during *kharif*, and in northern Punjab during *rabi*, too. This is a rational strategy for farmers who have more land than water and who face uncertainties of future supply and rainfall. Farmers who have access to supplementary supplies from tubewells or who somehow get extra canal water, tend to use the surplus on further increases in crop area.



Population increase in Pakistan's crowded urban centers is fast overtaking agricultural production.

The supply side of irrigation management will plainly have to be much improved to make canal operation more responsive to farming objectives and ease supply constraints on farmers by allowing better use of groundwater and rainfall, and by ensuring more reliable canal water supplies. Better communication between Canal Officers and farmers and more effective operation of canals will be essential. At present, general improvement of operation appears more relevant than emphasis on full demand systems or expansion into new areas.

While land is not an overall constraint, there are many areas where irrigated agriculture has been beggared by waterlogging, increased salinity and sodicity, and panning. The extent of the waterlogging problem is due almost entirely to methods of irrigation practiced. Proper water management should make waterlogging a rare occurrence except in depressions or in farms close to canals. Unequal distribution of irrigation water leads, however, to excessive use in many other areas — especially during the rabi season when the evaporation rate is lower.

The direct impact of salinity on yield appears secondary to waterlogging, mainly because farmers have learnt to keep salinity at bay by continuous irrigation of the same fields. However, this practice raises new problems when crops with differing water requirements are rotated. More research into the effect of high water tables on farm systems, as well as on individual crops, is needed before these problems can be tackled conclusively.

Drainage of the Indus Plains is slow. Flow paths often run to ground in interfluve depressions or are impeded by roads, railways and other built-up infrastructure. The spread of irrigation and its attendant spillage have greatly increased the volume of water which can only escape the land by being consumed or evaporated.

Subsurface drainage is now badly needed in those virtual disaster areas where the pre-monsoon water table has consequently risen to within 1.5 meters of the surface of land supporting dry-foot crops, bringing in its wake huge volumes of resident salinity towards the surface. Surface drainage alone should offer adequate return for protection of dry-foot crops from stormwater flooding. To be economic, drain capacities have to be kept to a minimum by better managing irrigation supplies to reduce the volume of waste water. Good design and operation of drainage systems can in turn help irrigation by keeping the water table at such a level that it maintains beneficial sub-irrigation and enables useable waste water to be returned to the irrigation system.

Disposal of saline drainage effluent poses special problems which can only be solved conclusively by passing as much of it as possible to the sea, either diluted in summer flood flows or, preferably, through the Left Bank Outfall Drain (LBOD) now under construction. At the same time, amounts of salinity mobilized by "vertical" drainage using tubewells should be kept to a minimum in rice lands or dry-foot crop areas that are not "disaster areas."

Here, horizontal drains, better water management and local reuse should suffice. The WSIP study recommendation is that tubewell drainage of saline water should be confined mainly to areas with access to the LBOD and the latter should be extended with this need in mind.

Flood control investment has tended to lag behind expectations in the past, though floods have claimed an estimated 6,350 lives since 1947 and have caused direct damage estimated at Rs 22 billion. The problem, however, is now being tackled under the National Flood Protection Plan II. Land-use zoning is also needed, to avoid flood damage on the scale experienced in 1988, when two floods caused damage costing nearly two billion rupees.

Flood protection and drainage can be categorized as environmental protection measures but the most pressing need under this heading is for watershed management. As experience in the Mangla Catchment has shown, such management can be highly cost-effective in reducing reservoir sedimentation, besides bringing benefits in terms of groundwater recharge and flood protection.

Other areas of environmental concern include the fate of new wetlands created by lack of proper drainage, which have assumed importance as feeding grounds for migratory birds, as fisheries and as sources of lift irrigation. Drainage of these areas is bound to have some adverse impacts but these can be minimized by proper planning and design and will be counterbalanced to some extent by environmental benefits.

Increased upstream development will also affect forestry and other activities in riverine and delta areas. In the delta, the problem is not so much seawater intrusion (already at its upper limit) as the threat of reduced flows in mangrove forests and associated fisheries. More studies are needed to guide work to stem further harm in these quarters.

Most of the problems highlighted in the WSIP study are numbered among the institutional constraints revealed in the course of reviewing ongoing projects. They include inadequate preparation of projects, inordinate delays in approving projects and underestimated costs. The latter problem stems partly from the former compounded by an incomplete understanding of the hampering effects of inflation and the levying of interest during construction. These problems at the initial stages of projects are later aggravated by further delays and oversights involved in obtaining high-level approval for every stage of procurement, lengthy land acquisition wrangles and funding shortfalls.

Events have overtaken the WSIP study observations on water apportionment disputes as a major planning snag, with settlement of the question at federal level at the end of March 1991 (see page 35). System operation in its institutional aspects, project preparation and project implementation assume renewed importance as areas for improvement, following this development.

A rise in system operation standards can offer considerable potential for all-round improvement but not until more reliable monitoring of flows, better communications and freedom to ease critical equity constraints come into play, along with advances in conjunctive use of surface water and groundwater.

Enhanced rewards and statuses for project designers could help get planning out of its present rut, where standard or type designs are too commonly relied on. Reliable feasibility studies and pricing procedures which allow adequate contingency margins are badly needed: hardly any of the projects submitted for inclusion in the WSIP study were adequately prepared. Guidelines for project preparation and approval are, therefore, a priority need.

Improvements in project implementation pinpointed by the WSIP study center on bidding procedures used by both Provincial Irrigation Departments (PIDs) and counterpart Provincial Agriculture Departments. Contracts handled by the PIDs tend to be for smaller, lower-cost (Rs 0.5 million or less) projects of short duration; these tend repeatedly to overrun their term, often by 100 percent or more. Larger (Rs 1 million plus) projects tend to meet their deadlines but have to be referred to higher authority for approval.

International competitive bidding for larger projects takes at least two years to pass all the stages involved, from prequalification through document preparation, tendering and award. Failure to take account of this time-lag is a frequent cause of miscalculations. Prequalification procedures tend to be anything but selective, offering no protection against unrealistic bids, unqualified contractors and time and cost overruns. The format of contract documents should, says the WSIP study, be improved to bind contractor and client to standard conditions, specifications, weights and measures, arbitration procedures and rates of interest on late payments. Tendering contractors should be required to submit a workplan and stick to it.

Many of the institutional problems affecting the sector can be addressed, ultimately, only by human resources development, particularly in the field of training. Most particularly, there is a need to overlap the teaching of irrigation and agriculture and to offer "sandwich courses in irrigated agriculture," to cater to the drive called for in the WSIP study toward increased agricultural production through system improvement.

More emphasis also has to be placed on pre-service and in-service training, for diploma-holders and graduates alike. Schemes started up under the Irrigation System Management project have given training a boost, but this must be sustained and extended to include training of technicians.

Khalid Mohtadullah was formerly General Manager (Planning) of Pakistan's Water and Power Development Authority and was responsible in this capacity for supervising WAPDA's inputs into the WSIP study and publication of the results. With effect from May 1991, he moved to Sri Lanka to become IIMI's first Director for Research.

Interactions between institutions and farmers over such matters as delivery and disposal of irrigation inputs and outputs, farm management as a business, farmer support and advisory activities, must be recognized as an obligation upon irrigation departments, no less than the straightforward delivery of water to the canal outlet. Although the Water Users' Association Ordinances provide some basis for communal self-help efforts to improve, operate and maintain watercourses, it is the irrigation department in the person of the Canal Officer that retains institutional control over public water supply and drainage.

The role of agriculture departments in relation to that of irrigation departments requires clarification of a kind that will encourage Canal Officers to recognize the agricultural aspects and objectives of their duties, concerning themselves with water management problems above and below the canal outlet. This should allow the agriculture departments to concentrate more resources on involving farmers and Water Users' Associations (WUAs) in management of problem-solving, in addition to offering general advice and support in such areas as watercourse improvement.

On-farm water management appears best left in the hands of agriculture departments, within which it should be recognized as a development activity akin to Canal Water Management. The extension role of agriculture departments should be strengthened in its irrigation aspects by the formation of water use and soil reclamation units. The long-term goal of the Canal Water Management project should be farmer joint management — farmers advised by agriculture departments and sharing with irrigation departments — the job of managing the canal and drain system.

In this scenario, the irrigation department would provide executive control over the big picture of delivery and disposal of inputs and outputs. Outside the official sphere, farmers require successful interaction with other farmers, traders and credit institutions. Much more support for WUAs is required before they can participate fully in long-term institutional development.

Research into irrigated agriculture is presently carried out by many agencies, academic institutions and project bodies. Though parts of the research enterprise are coordinated, this is not true of much work done in a project context. Many topics urgently need researching but there are too many gaps in today's effort. The greatest unfulfilled need is probably in the realm of whole farm operation; top priority should be given to adaptive research in this area.

There is a wasteful tendency for model research farms and allied institutions to live on long after their original experimental function ceases: here, too, the WSIP study suggests, some rationalization is long overdue.

Finally, financial constraints arise mainly as a result of inconsistencies between budgeting assumptions applied at different levels of planning. Present funding of investment through federal and provincial Agricultural Development Plans (ADPs) is based on an overall budget for the sector set by federal government officials.

Individual provinces plan their investment finance within this estimated budget, but then usually have to cut them pro rata to fit real fiscal circumstances. Longer-term planning of investment is effected through the five-year national plan cycle and there have been changes in this process where the handling of inflation is concerned. The Sixth (1983-1988) Plan was expressed in both constant (1982-1987) price levels and current prices (including inflation) but the Seventh Plan was expressed only in constant price (1987-1988) levels.

As in the case of the Agricultural Development Plans, the Five Year Plan is based on the federal government's estimate of available resources and several reiterations of the process whereby investment put up by provincial and federal agencies is fitted within real resources. It is hard under these circumstances to maintain a steady supply of funding to each project, or even to ensure project costs have been fully updated. Project funding is consequently often overstretched, incurring additional time-related costs and interest during construction and inflation.

These constraints can cause net losses to the economy approaching almost a quarter of the investment allocated to projects in the first place, in many cases entirely robbing them of their cost-effectiveness. There is a pressing need to find rational ways to avoid this trap if the nation is to continue to provide for itself beyond the present decade.

FMIS WORKSHOP IN ARGENTINA

Mendoza, a city in west-central Argentina in the foothills of the Andes will be the venue for an international workshop on performance measurement in farmer-managed irrigation systems from 12 to 15 November this year, organized jointly by the International Irrigation Management Institute (IIMI) and the Institute Nacional de Ciencia y Tecnica Hidricas (INCYTH).

More than 30 per cent of the irrigated area of Argentina is in the province of Mendoza. The name of the province and its capital city both derive from Pedro de Mendoza, the Spanish soldier and explorer who founded the first European colony in Buenos Aires around 1536. When the first Spanish conquerors arrived in Mendoza they found an already irrigated area of some 5,000 ha in the province, whose climate was arid, with an average annual rainfall of about 300 mm. Today all the available surface water and groundwater in the province is used to irrigate some 360,000 ha.

Farmer-managed irrigation systems (FMIS) also classified as small-scale irrigation or minor irrigation systems may be found with command areas of 15,000 to 20,000 ha. FMIS are also popularly described as traditional, indigenous, communal or people's systems. In these systems most management activities are carried out and decisions made by the farmers themselves. FMIS cover a wide range of environments and technologies and in many countries they contribute to the production of a significant portion of the subsistence food supply. Some FMIS are hundreds of years old, well-managed and very productive while others perform far below their potential. In many developing countries FMIS cover large areas with a great number of beneficiaries, not only in relative terms, but also in absolute terms. FMIS represent a sector in which there is much scope for performance improvement with a relatively low level of investment.

As many FMIS do not perform as well as they should, there is a need to identify the areas in which they fall short of their potential. It is therefore important to measure and evaluate their success or failure objectively and identify specific areas in need of improvement.

The specific workshop objectives will be to exchange experiences and ideas on criteria best suited to achieve distinct goals and objectives and to come up with a set of indicators based on them, which are manageable within the existing framework and data constraints for assessing FMIS performance; to discuss and develop appropriate cost-effective methodologies for the collection of data relevant to the proposed performance indicators; to review case studies of the performance of different FMIS and synthesize their findings to draw general conclusions and recommendations; to create the awareness that performance evaluation is an important factor in ensuring goals of economic viability, social equity and sustainability and to discuss the possibilities of generating future programs for action in performance and evaluation of FMIS.

COUNTDOWN

Canal irrigation in Pakistan builds on six recorded centuries of experience. Yet long before historic time, irrigator cultures thrived in the Indus Basin, using and capturing floodwaters and alluvium like other early civilizations in the valleys of the Nile, Tigris and Euphrates — the "fertile crescent" of antiquity. Some of the earliest known urban centers (including Harappa, whose ruins can be seen to this day near Multan) were founded in the Indus floodplain. Forces unknown (but thought to include flood disasters) destroyed these ancient communities; yet there was still a prospering agriculture based on flood capture on the banks of the Indus when the invading forces of Alexander the Great crossed and recrossed the river 23 centuries ago.

1351 Feroze Shah Tughlaq constructs Western Jamna Canal.

1568 Emperor Akbar improves Western Jamna Canal.

1633 Shah Jahan constructs Shah Nehr (Royal Canal) to bring waters of the River Ravi to Shalimar Gardens.

1846-80 British annex Punjab. Napier constructs Bari Doab (1859) and Sirhind (1872) canals. Fife and others improve canals in Sindh (1855) and NWFP (from 1880).

1878 Severe famine prompts construction of Sidhnai (1886), Lower Chenab (1892) and Lower Jhelum (1901) canals.

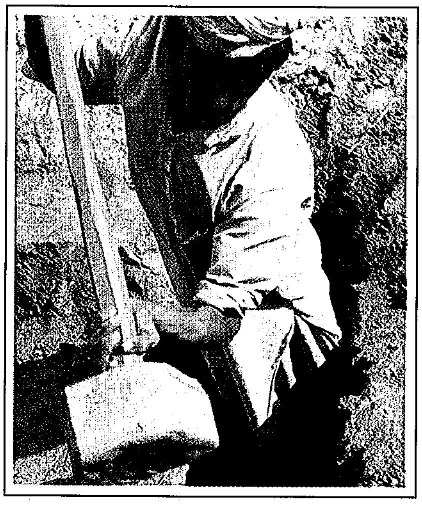
1900-30 Triple Canal project integrates three rivers — Jhelum, Chenab and Ravi — by constructing control works at Mangla (1905), Marala (1905) and Balloki (1907) and operating the five Link Canals (UJC, LJC, UCC, LCC and LBDC) as an integrated system. Three major new canal systems are constructed in Punjab, and the Sutlej Valley canal system created by four barrages and the Upper Swat Canal developed in North-West Frontier Province (NWFP). A major barrage and seven main canals, totaling 14,000 km, are constructed in Sindh. Central Indus plain becomes the subcontinent's breadbasket.

1935 Anderson Report leads to settlement of Sindh/Punjab allocation dispute and construction of the Haveli Canal.

1946 Rao Commission set up to settle division of Indus waters after forthcoming partition.

1947 Independence and partition.

1952-54 Indo-Pak disputes over water allocation persist.



Farm labor, North-West Frontier Province

1955-59 New Link Canals are constructed to resolve disputes.

1960-63 Soil surveys reveal widespread salinity with waterlogging threatening more than one third of Pakistan's irrigated area. Salinity Control and Reclamation Projects (SCARP) are launched with construction of a network of deep public tubewells to help drain high risk areas.

1979 Revised Action Plan for Irrigated Agriculture proposes new targets for water development nationwide. Injections of rural development credit spur rapid growth of private tubewells.

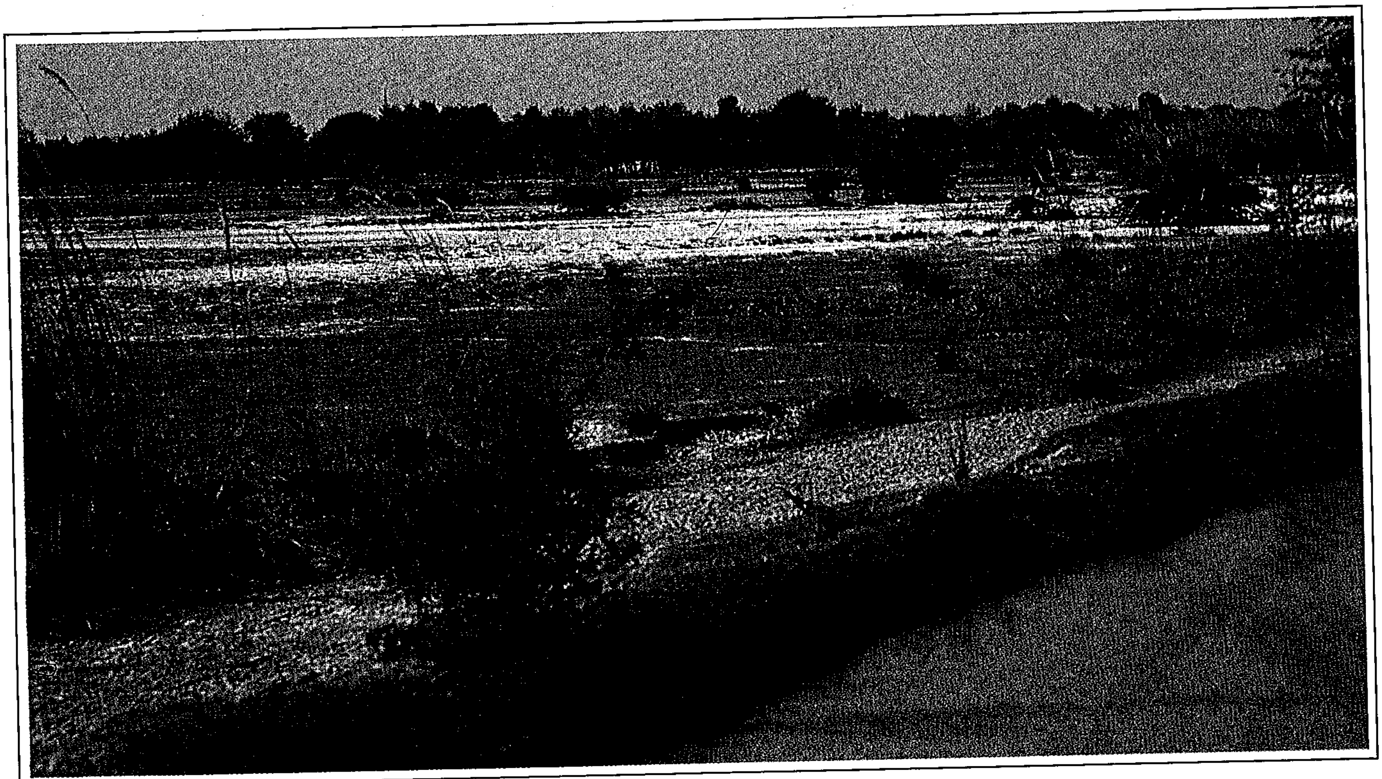
1981 Water Users' Association Ordinances formalize representative farmers' groups following pilot projects in Punjab and Sindh.

1986-87 Government policy switches to divesting state of public tubewells (SCARP Transition Program).

1988 Report of the National Commission of Agriculture targets 5 percent growth rate in total agricultural production by the year 2000.

1990 Water Sector Investment Planning Study highlights need to manage Indus Basin water as a unit and tailor irrigation to agricultural growth.

1991 Settlement of interprovincial disputes over water.



Up to a third of Pakistan's irrigated land lies prone to crop-killing salinity and sodicity syndromes.

Secondary Salinity in Pakistan — Harvest of Neglect

by Jacob W. Kijne and Edward J. Vander Velde

Early in 1989 with funding from the Netherlands, IIMI Pakistan began a five-year study, into what has frequently been described as the "twin menace" of waterlogging and salinity. These are syndromes that have long afflicted vast areas of irrigated farmland in Pakistan. Could improved irrigation management help minimize them? The study's aim has been to identify, through detailed investigations in Punjab and Sindh provinces, new kinds of management interventions that might help keep these problems under control, followed by a second phase of action research to field-test promising remedial approaches.

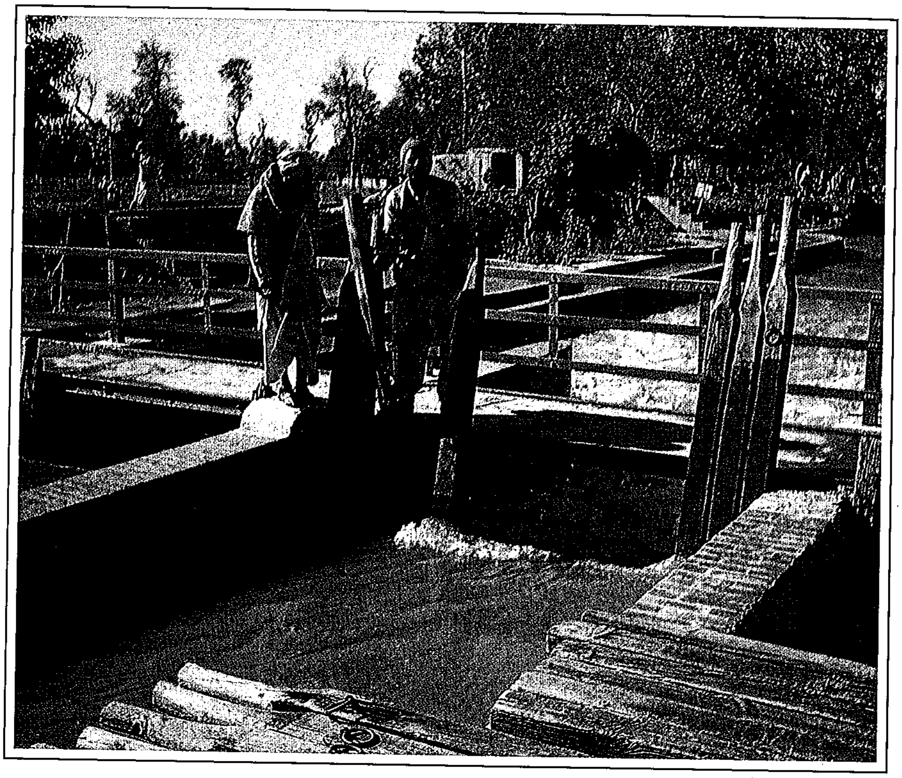
At the project design stage, it was not appreciated that salinity in Punjab is now largely dissociated from waterlogging. Since the 1960s waterlogging has been greatly reduced by the installation and operation of public sector deep tubewells as part of Salinity Control and Reclamation Projects (SCARP). More recently, fast-growing use of groundwater for irrigation from privately owned shallow tubewells, now numbering almost 300,000 countrywide, has greatly multiplied the "vertical drainage" effect of SCARP tubewells.

IIMI's research as originally proposed was to focus on: "irrigation and drainage conditions of incipient and not yet apparent waterlogging and salinity problems." The sites selected in Punjab were distributary canal commands served by Gugera Branch Canal in the Lower Chenab Canal (LCC) system in the Rechna Doab, where studies on canal system performance and constraints to irrigated agriculture below the outlet were already well underway. By 1989, field observations and a body of anecdotal evidence from farmers indicated that these areas harbored a suitable range of incipient salinity conditions.

Further surveys revealed, however, that water tables were commonly more than three meters below the soil surface in these locales, rendering incipient waterlogging unlikely. That condition, however, did not disqualify the chosen command areas as fitting places in which to address key salinity issues. On the contrary, data collected for other IIMI research projects were beginning to reveal largely unrecognized salinity problems in both places despite the absence of waterlogging.

We reason that this phenomenon results from widespread and increasing reliance by farmers in the lower reaches of canal commands, upon tubewell water of often marginal or poor quality for irrigation. Tubewells have become the farmers' response to increasingly inadequate and unreliable deliveries of good quality canal water proceeding down the system, the distributary and the watercourse.

The topography of the Rechna Doab is relatively flat with little natural drainage. It is underlain by a deep, high-yielding aquifer that is mostly coarse and sandy but contains occasional thick clay layers that must be screened-off when tubewells are installed. Nowadays most water tables in the Mananwala and Pir Mahal commands are three to eight meters deep, grading towards the tail ends of these distributaries.

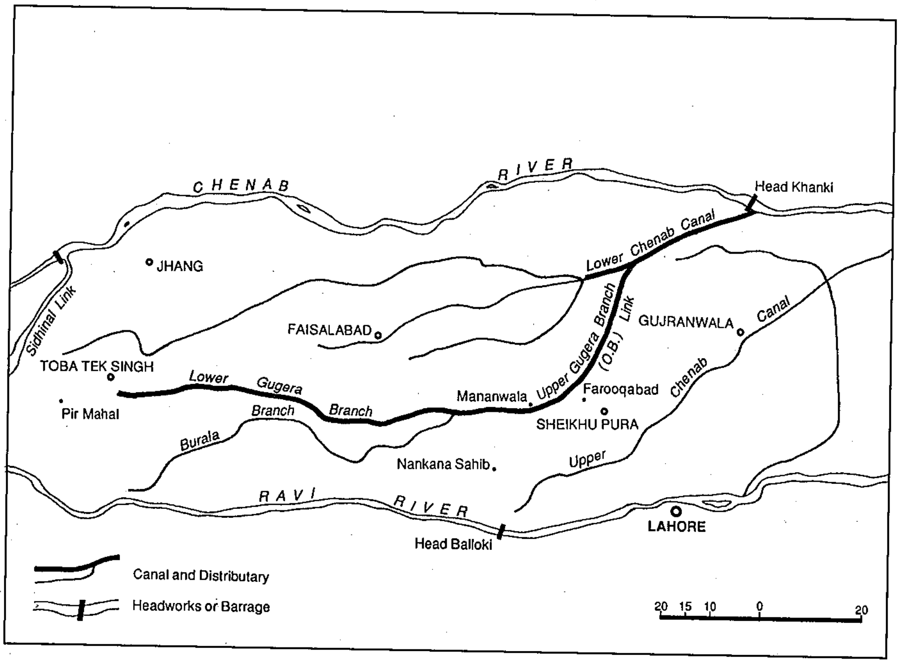


Using wooden billets to augment flow levels – an improvised response to deterioration of elderly control structures in Punjab.

Primary data for surface and tubewell water supply over several seasons have been collected by IIMI and its research collaborators in the Punjab Irrigation Department, for a large sample of watercourses off-taking from Lagar and Mananwala distributaries in Farooqabad Sub-Division, and from Pir Mahal and Khikhi distributaries in Bhagat Sub-Division in the LCC system (see map).

In size and service area, both Mananwala and Pir Mahal are fairly typical distributaries in the LCC system; Lagar is somewhat smaller. In both subdivisions, public tubwells were initially installed to control waterlogging. More recently, private tubewell development has been extensive and rapid; densities of 5-7 wells/100 hectares are now common locally.

Mananwala Distributary is located in the Punjab rice-wheat agro-ecological zone. Rice (especially the high value *basmati* variety) is the predominant crop here during *kharif* season (mid-April to mid-October) wherever irrigation is sufficient, while wheat is the principal crop in *rabi* season (mid-October to mid-April).



Rechna Doab, Punjab, Pakistan.

(Continued on page 20)

DECISION DECADE

by Robert Lamb

More than 150 leading stakeholders and operators in Pakistan's giant water sector met in Islamabad from 12 to 14 March to discuss a major study on Water Sector Investment Planning (WSIP) to the year 2000 and beyond (see page 9, this issue).

The Consultative Meeting, co-hosted by the Ministry of Water and Power and the Ministry of Planning and Development, set about gleaning a number of strategic objectives from the study for coming decades. Sharing the top of the list of goals that emerged from the meeting were the meshing of irrigation operations with crop production requirements and basin-wide management of water resource use.

Pakistan's Minister of Finance and Economic Affairs, Senator Sartaj Aziz, gave both these calls a surprise boost in his inaugural address by announcing that an end was in sight to the bitter inter-provincial water apportionment disputes that have plagued implementation of various national development plans since Independence, and that "...a solution of this issue, acceptable to all parties and in the best national interest" would be announced "very shortly."

Conjunctive use of surface water and groundwater was characterized as the main key to future growth and change in irrigated agriculture in Pakistan, along with urgent action to combat salinity and a crash program of water use monitoring and data management.

The meeting was an occasion for frank expression of strongly held views. Nobody doubted the glowing potential for a boom in irrigated agriculture in Pakistan but remedial mechanisms that might implement the study's recommendations were not clearly prescribed.

Pakistan's population is expected to double in the next 22 years — 145 million by the year AD 2000, 207 million by AD 2012 — and to cope with this agricultural production must grow from its present 60 million to 98 million tonnes a year. Secretary of the Ministry of Water and Power, A.R. Mahsud said the more than 4 percent annual growth requirement these figures implied was presently out of reach.

"The 1.5 percent annual increase in yield foreseen in the Revised Action Plan is unlikely to be achieved," he warned, "and even if we manage that we'll still be up to 36 percent in deficit by AD 2013." The way out he said, was to harness the power of irrigation to multiply agricultural yields and income.

Welcoming the WSIP study as "a very useful basis" for this process, Minister Aziz highlighted the need to protect the environment and ensure long-term sustainability while striving to raise yields.

"We have not yet achieved the breakthrough to the sustainable, integrated management approach," he asserted. "Ineffective system operation and maintenance mean we capture hardly 60 percent of available water supplies."

He mourned the water resources lost because provinces had failed to agree on apportionment but added: "I was struck by the figures in the study showing the relatively small amount of water that is causing all these problems. Three or four times the disputed amount could have been achieved simply by proper operation and maintenance." He urged global support to help: "...telescope and remodel current development programs so we can regain lost time."

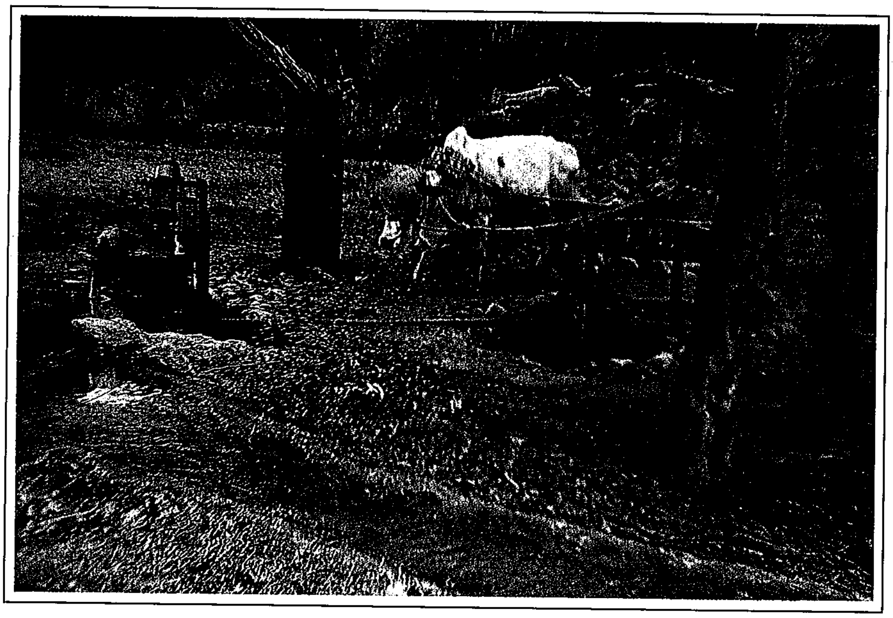
World Bank Director Michael H. Wiehen said most of the conclusions of the WSIP study were not new. Three earlier studies had offered similar diagnoses and national plans had followed their recommendations, yet a single acre-foot (1,231 cubic meters) of water in Pakistan's irrigated farms was now producing less than the equivalent of US$100 worth of crops, compared to US$500-1,000 worth typically achieved in countries with similar or fewer natural assets.

"The quality of life in rural areas remains low," said Wiehen in a hard-hitting speech that hinted at a risk of "donor fatigue" unless swift change materialized in the water sector. Applauding federal moves to call a halt to water disputes, Wiehen said outputs worth at least US$500 million a year had been lost when disputed loads were simply shed unused.

UNDP Deputy Resident Representative Cornelis Klein said there were some new elements in the WSIP study that merited fresh attention. He noted the lack of erosion protection measures in fragile terrains and the need to improve irrigation management for the direct benefit of farming rather than for the pursuit of technical perfection.

Presenting the study, the water planning chief of the Water and Power Development Authority (WAPDA), Khalid Mohtadullah said it underlined lessons learned since 1979. It called for a new commitment to manage by objectives, unblock institutional bottlenecks and get real value for money from investments in the water sector.

In practical terms, he saw drainage, floods and sedimentation as key issues. He stressed the need to inject priority funding into canal and watercourse improvements in saline



The traditional 'Persian Wheel' lift device is still seen in parts of Pakistan's countryside...

"disaster areas" rather than in fresh groundwater areas, since seepage into the latter simply recharged the usable part of the aquifer. Continuing privatization of tubewells should be encouraged, he said, and investment in surface drains stepped up. He announced that an environmental audit leading to a National Drainage Plan was under consideration.

Also needed, said Mohtadullah, was a much improved information base to anchor feasibility studies used to validate new and ongoing irrigation projects. He called for more human resource development — training managers and educating farmers to make irrigated agriculture prosper sustainably.

Top administrators from Pakistan's four major provinces had mixed reactions. Some dissented from the proposed focusing of investment on distributary and watercourse improvement in saline groundwater areas, lest this should skew distribution of funding.

Punjab's R.K. Anwar, Secretary of the Irrigation and Power Department, observed that because criteria for project evaluation differed from province to province, well-designed projects proposed by one province were frequently displaced by flawed proposals from elsewhere to satisfy political pressure to disburse funds evenhandedly.

He favored allocation of development funding among the provinces in proportion to traditional or historic rights in water, leaving them to decide how to manage both. Anwar affirmed that Punjab was going ahead with its program to improve the cost-effectiveness of irrigation by turning over all its remaining 12,000 public tubewells to private owners.

Ghulam Mustafa Abro, Chief (Water), Planning and Development Department, Sindh Province, was sympathetic to the idea of basin-wide planning so long as implementation remained a provincial concern. The study paid insufficient heed to socio-economic hardships in his province, he said.

"Provincial needs differ dramatically from the North to the South of the country" he asserted. "Sindh is landed with the saline effluent of all the other provinces, but we lost two million acres of land previously irrigated by river floods after the major barrages were constructed upstream. Nothing was done to bring relief to the poor who lost their livelihoods as a result. Now remote sensing shows that half the mangrove ecosystems of the Indus Delta, on which thousands of fishing and other communities depend, have disappeared in the past ten years and salt intrusion from the sea remains a threat. We also have to cope with an influx of refugees from disorder in neighboring lands. The fears of Sindh have not been confronted in this study."

Akhtar Ali Ismaili of North-West Frontier Province's Irrigation Department proposed scientific, demand-based water allocation and supported the lining or relining of all distributaries and watercourses in saline areas, but wanted the major Left Bank Outfall Drain project to remain under provincial rather than federal control. He, too, entered a special plea for his province's unique features — heavy reliance on lift systems and a need for antierosion measures.

Representing Baluchistan, Munawar Khan Mandokhel, of the Irrigation Department said that the WSIP study laid heavy emphasis on the concerns of major irrigated areas in the central basin. Some 20 million acre-feet (25 billion cubic meters) of water were lost in flash floods in Baluchistan in a typical year. This water if properly harvested could be used to irrigate more than two million hectares of land presently lying idle in the province.

World Bank expert S.S. Kirmani (see page 5, this issue) made an eloquent plea for an end to strife over water. Water is a national resource and a national concern, he asserted, while ways and means to upgrade irrigation and agriculture are provincial matters.

"Water is there for the common good and the federal government should provide arbitration mechanisms if competing parties can't agree, in keeping with the best Islamic traditions," he insisted. He suggested that Pakistan's strategy should be to redefine the objectives of irrigation in terms of nationwide gains in agricultural production, with greater responsibility and accountability on the part of Provincial Irrigation Departments (PIDs) when it came to delivering supplies in timely and equitable ways.

"It's no use blaming the PIDs when this doesn't happen, if we don't equip them to deal with the problems. There is plenty of talent in the PIDs but are we supplying them with the means to put their talents to good use?"

Taking up the institutional theme, World Bank consultant A.A. Abidi noted that the confidence to make significant policy and planning changes work at system and farm levels had to be based on a measure of self-esteem, but Pakistan's present bureaucratic environment denied the effective irrigation manager due reward and recognition. Institutional traditions of excellence had slipped and this decline had to be arrested if Pakistan wanted to count on human capital of a quality needed to raise national output to safe or surplus levels. Similar constraints were, said Abidi, being placed on Pakistan's planners. He called for new incentives to help revitalize the Provincial Planning Cells.

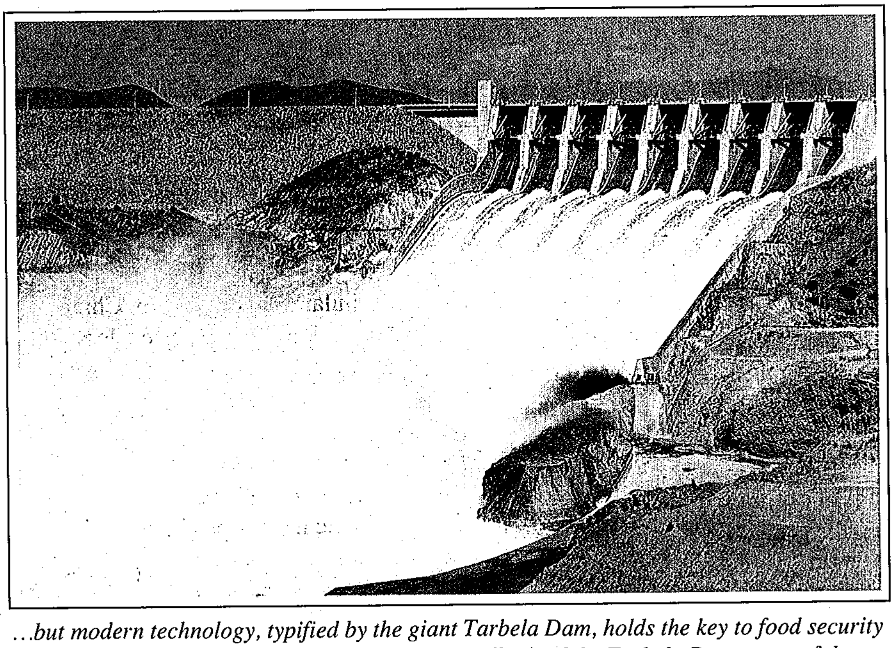
A working paper on Investment Planning Issues, by Dr. Richard H. Goldman, Harvard University, analyzed water sector investments cataloged in the WSIP study. Projects aimed at increased crop production (whether from growth in irrigated area, extra water or increased water delivery efficiency) formed 20 percent of the portfolio. Infrastructural improvements such as canal repairs or better storage provisions accounted for 40 percent of projects, while 35 percent were directed toward protection of crops from waterlogging and salinity. The remaining 5 percent were aimed at projects involving multiple use of rice fields by removing excess water and boosting the rate of soil drying for a subsequent crop.

These figures to some extent reflected strategic priorities and relative rates of return on investment in these different categories of project but project selection was still strongly influenced by other noneconomic criteria.

Goldman highlighted glaring inconsistencies in basic data and methodologies applied to project preparation. Also lacking was regular feedback on project performance. A computer model developed in the course of the study, known as the Indus Basin Model (Revised) remains available to help planners select a "shopping list" of projects that more closely matched strategic needs and gave best value for money, he pointed out.

Ongoing projects were, according to Goldman, running into serious implementation delays, with construction periods roughly doubling in many cases while establishment costs continued to rise. The official practice of levying Interest During Construction on project funds, while not unique to Pakistan, encouraged delay and meant costs outstripped benefits to a point where many projects were scarcely viable.

Several speakers warned that if Pakistan fails to surmount the many obstacles to equitable, productive and sustainable use of water resources shown up by the WSIP study, the country will be faced with runaway food import bills before the end of the decade or, at worst, by the grim specter of famine. Shams ul Mulk, Member (Water), WAPDA spoke for many when he stated: "The stakes are so high, the prospects of failure so unacceptable, that there can no longer be any excuse for inaction."



...but modern technology, typified by the giant Tarbela Dam, holds the key to food security if tempered by wise management. ***Photo****: A spillway of the Tarbela Dam – one of the largest earth-filled dams in the world by: Directorate of Films and Publications, Ministry of Information and Broadcasting, Government of Pakistan, Islamabad.* ***Courtesy*** *– The High Commission of Pakistan, Sri Lanka.*

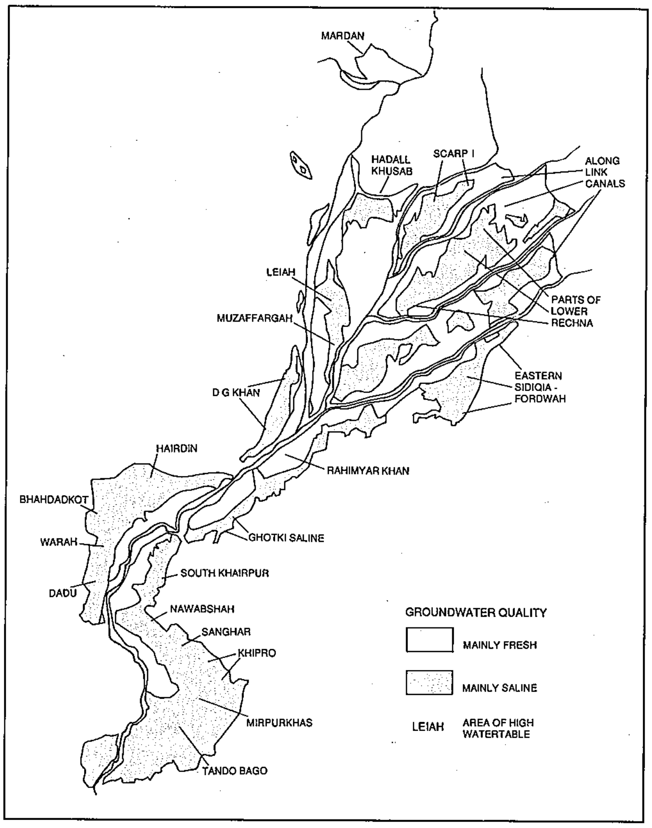
(Continued from p. 16)

Pir Mahal distributary lies in a transition area between this rice-wheat region and the cotton-wheat agro-ecological zone further to the southwest. There, cotton is more frequently the main kharif crop, though wheat still predominates in rabi. In addition, sugarcane, various fodders, seasonal fruits, oilseeds and vegetables are grown for cash income and domestic use in both distributary service areas.

Large Distributary canal commands like those of Mananwala and Pir Mahal are the "building blocks" of irrigated agriculture in the Punjab. Findings from earlier IIMI Pakistan research on the operations and performance of these and other distributary canals in the LCC system showed that the long-standing system performance objective of equity in surface water distribution is now rarely achieved and almost never sustained. Outlets in the tail reaches of distributaries seldom obtain more than a fraction of their authorized discharge at the *watercourse head*, in contrast to outlets in the upper reaches which commonly receive substantially more than their design discharge. It is clear that consistently low levels of maintenance inputs into distributary canals is a primary cause of this condition.

The consequence is that farmers in the command areas of tail watercourses have, on average, less than one-fifth the access to surface water supplies enjoyed by farmers served by watercourses in the head reach of the distributary. When discharge at the distributary head falls below 70 percent of design, water supplies to tail outlets simply collapse, and farmers there receive no water from the canal at all.

In Bhagat Sub-Division, surface water supplies delivered by Lower Gugera Branch to the tail of the main system are usually insufficient for all six distributaries to operate simultaneously at full supply level. Consequently, an inter-distributary program of rotational operations is followed for much of the year at Bhagat Head.



Saline groundwater areas and principal areas of high water table.

Data obtained for several months in 1990 revealed significant inconsistencies in the equitable implementation of scheduled rotational operations. Pir Mahal Distributary operated about 40 percent of the period below 70 percent of full supply. This contrasts sharply with the near continuous operations of neighboring Khikhi and Dabanwala distributaries at 90 percent or more of full supply discharge.

Heavy silt accumulations and embankment erosion, resulting from deferred or neglected channel maintenance, also plague Pir Mahal's operation. In response to these conditions, an internal rotational delivery program between the main channel's tail reach and its off-taking minors was adopted. But one result of such operations is that the frequency of days without canal water at watercourse heads increases markedly in the distributary's tail reach, where most farmers are without surface water supplies for as much as or more than half the year.

Yet when distributary head discharge conditions are relatively steady at or near design full supply level, tail watercourse commands often continue to be deprived of even the modest surface water supplies they may otherwise receive, through the cumulative effects of many large and small unauthorized or informal withdrawals of canal water upstream. Variability in distributary flows upstream is also passed on to the discharges of downstream off-taking watercourses. The effect is most pronounced for tail-reach outlets, and farmers in those command areas experience the further disadvantage of greater uncertainty of delivery of whatever share of surface water supplies reaches them.

In the face of the vanishing supply of surface water to many watercourse heads in the lower reaches of distributary canals for much of the year, the only obvious response farmers have to meet the irrigation water requirements of their crops is groundwater development.

Extensive public groundwater development in large areas of the Rechna Doab commanded by the LCC system — the SCARP deep drainage tubewells — initially provided greatly enhanced water supplies *at the watercourse level* and spurred two major, near simultaneous changes in irrigated agriculture, that soon spread throughout much of Punjab. A three or fourfold increase in water supplies at the watercourse level meant that the low design (50-75%) cropping intensities supported by the surface irrigation system could be exceeded. Annual cropping intensities in many LCC distributary commands rose rapidly to well over 100 percent. Surpluses of irrigation water now also means farmers can plant larger areas in higher priced, water-intensive crops like rice and sugarcane.

Amounts of fresh groundwater pumped by these deep tubewells have dropped sharply because of design and maintenance failures in bores and machinery, coupled with high operating costs that fail to redeem revenues from water charges. But that decline does not mean that water supplies to the farmer from this source have become insignificant. An earlier study showed that public tubewells in Lagar Distributary still provided about 43 percent of all irrigation water available to farmers in rabi and nearly 30 percent of irrigation supplies in kharif. Even so, there has been a sharp overall fall in amounts of water pumped from the remaining operable public wells.

Rapid development of private, shallow tubewells throughout the 1980s cushioned the declining productivity of deep public tubewells and helped farmers maintain high cropping intensities of less drought-tolerant crops, particularly in Punjab. A tubewell census of 35 watercourse commands of Mananwala, Karkan (Minor) and Lagar distributaries revealed that the average density of private tubewells in Farooqabad Sub-Division is about 5 per 100 ha of gross command area. This density of private tubewells, in a SCARP zone where private well installation was formally restricted and controlled, is considerably higher than published official data suggest.

Hence, the actual availability of water in watercourse command areas continues to greatly exceed the original surface system design values of 1 liter per second per 5 or 7.5 ha. IIMI studies also show that, on average, groundwater from public and private sources contributes about 70 percent of the total irrigation water used in irrigated agriculture in Farooqabad Sub-Division. This implies a much larger use of groundwater as a fraction of total irrigation supplies in many canal command areas in Punjab than heretofore suspected. The figures also suggest that aquifer exploitation may already exceed recharge, at least locally if not over larger areas. Investigating water balances in our sample watercourse command areas, we have observed substantial variability in watercourse and tubewell discharge. Variability in watercourse discharge is largely a function of distributary performance. Variability in tubewell discharge results from variations in pumping efficiency such as those caused by throttling down or voltage dips, or by long-term motor wear and screen deterioration.

Over the past two and a half years, the operations of several hundred tubewells in IIMI research sites have been monitored throughout both systems, through interviews and various metering techniques. These data now provide the most complete information on tubewell irrigation operations within surface system canal commands available in Pakistan. They can be used to assess the water balance in specific watercourse commands, providing important insight into water losses to groundwater that contribute to aquifer recharge and possible water table rise as well as to the proportions of canal and groundwater used by farmers for irrigating their crops.

Although the average seasonal irrigation for the same crop in Mananwala and Pir Mahal commands was found to be about the same, variability in seasonal irrigation was greater in the former case. Farmers in Pir Mahal appear to strive to make more optimal use of their irrigation supplies, perhaps because surface deliveries in this distributary are somewhat less reliable. Some components of the water balance for watercourse commands have been deduced from previous studies done elsewhere in Punjab. Losses from non-rice crops also depend upon the assumed value of field application efficiency and modeling studies show that losses from these crops depend on soil characteristics as well. Losses from rice fields were measured during kharif 1989 and 1990 from the rate of decrease of water levels in ponded rice fields, corrected for evaporation losses. Results from a Mananwala watercourse indicate that conveyance losses and percolation from rice fields contribute most to groundwater recharge.

In general, in a single kharif season, recharge and discharge from the aquifer appear to balance. Over an extended period of several seasons, however, there is a clear downward trend in water tables in the tail watercourses of both Mananwala and Pir Mahal, though more pronounced in the latter. The contribution of rainfall to water table rise so far remains uncertain but appears to be fairly modest, in view of the fact that no sharp rise in water table was observed after a 100-mm storm early in the study period, or from later smaller storms.

The suitability of irrigation water for agriculture should be evaluated on the basis of specific conditions of use, including the crop(s) grown, soil properties, climatic factors, irrigation management and other cultural factors. Published salinity tolerances of agricultural crops generally apply from the late seedling stage to crop maturity, although it appears that tolerance at germination and early seedling stage may be lower for some ostensibly more tolerant crops.

In Pakistan, three well-known criteria are used for classifying the suitability of water for irrigation use. They are electrical conductivity (EC), residual sodium carbonate content (RSC) and the sodium absorption ratio (SAR). Unfortunately, somewhat outdated norms remain in use. For example, the upper limit for "good" water is an EC of 1.5 deciSiemens per meter (dS/m, equal to mmhos/cm), an RSC of 2.5 meq/l and an SAR of 10.

By contrast, current FAO guidelines for interpreting water quality for agriculture set the upper limit for unrestricted use at an EC value of 0.7 dS/m, or less than half the value considered safe in Pakistan.

The effect of sodium, as expressed in the SAR value, depends on the EC value, but a general upper limit would nowadays be set at 6 or 7, again much less than the SAR value of 10 still used in Pakistan. For sodic waters, common in much of Punjab, an *adjusted* SAR is now generally recognized as a better index, and the SARs of typical tubewell waters increase by around 25 percent when they are calculated as adjusted SAR values. Thus, it is inadvisable to classify tubewell water with SAR up to 10 as suitable for irrigation use undiluted. The prevailing view of Pakistan's Water and Power Development Authority (WAPDA) is that "...usable waters are not expected to create any salinity or sodicity problems in the soil and can be safely used to raise all types of crops climatically adapted in the area even without mixing with canal water *provided efficient drainage is practiced.*" However, in water-short environments such as the tail ends of distributary canals and watercourses, drainage is obviously rarely practiced nor often required (from a purely hydrological viewpoint) because surplus water is seldom present. Moreover, there are also scant opportunities in these locations to implement the recommended practice of mixing canal and 'marginal' quality groundwater in 1:1 ratio.

As part of their collaborative research on groundwater irrigation systems, IIMI and the Irrigation Research Institute (IRI) of Punjab Irrigation Department evaluated water quality in about 40 percent of all tubewells in the command area of the Lagar Distributary in 1988 and 1989. A similar evaluation of tubewell water quality was completed in 1990 for selected watercourse commands of the Mananwala-Karkan distributary system. Data for 430 tubewells, over 90 percent of which are private, are now available.

Analysis of these data has revealed very significant differences between mean values of tubewell water EC and SAR for head, middle and tail watercourse commands, pointing to a sharp deterioration of tubewell water quality toward the tail ends of distributaries.

Agricultural Engineer Jacob W. Kijne is a Senior Irrigation Specialist and the new Director of IIMI Pakistan, and Geographer Edward J. Vander Velde is completing his fifth year as an IIMI Irrigation Specialist in Pakistan since 1986.

Substantial research on aquifer behavior is plainly needed before the cause of this marked decline can be established with certainty. Nonetheless, it appears significant that most private tubewells in the command areas of the distributaries in question were installed fairly recently. About 40 percent of those in head and middle reach watercourses became operational after 1987, compared to a mere 11 percent at the tail. By contrast, 40 percent of the private wells in tail reach watercourses were installed before 1985, but only 20 percent and 6 percent, respectively, in middle and head reach service areas, are more than 5 years old. Farmers served by tail watercourses evidently felt a need to install tubewells sooner than those located elsewhere in the distribuatary commands — hardly a surprising choice, since it is likely they began experiencing persistent shortages and greater variability in canal water supplies much sooner.

Thus, insofar as deterioration of groundwater quality may prove to be related to seepage of saline water from lands irrigated with marginal or poor quality tubewell water, it would seem that the process is relatively rapid. Public tubewells typically tap aquifers in the range of 15-30 m. With the water table at about 5-m depth, it has taken only 5 years (the median age of tubewells in Mananwala's tail reach) for groundwater quality to worsen down to at least 15 m.

To assess the likelihood of salinity problems for conventionally irrigated and established crops, the mean salinity of the major root zone, where most of the water extraction occurs, must be determined. In one third to one half of all fields sampled in the tail watercourse commands, profile salinity was found to be great enough to reduce crop photosynthesis even when the soil was at full field capacity. Unexpectedly, profile salinity in 5 percent of the fields sampled in middle-reach watercourse commands, had also reached this level, with highest readings concentrated in surface-water-short tail areas of those watercourses. Under such conditions, crops are stressed even though there may be plenty of moisture in the soil.

It is therefore no surprise to find that crop yields in these locations fall well below expectations. For the average conditions represented by our samples and a medium salt-tolerant crop such as wheat, an ECa (apparent EC) of 10 dS/m could be expected to cause a reduction in yield up to 40 percent or a decline of as great as 60 percent in the yield of sugarcane, which is more sensitive to salinity (these are indicative values only since the salinity tolerance of crops can vary with ambient agronomic conditions, cultivation practices and other production limiting factors).

Field observations also point to a structural decline of soils resulting from irrigation with sodic waters, a complication which poses an important obstacle to reclamation of saline soils by leaching. Sodicity may induce calcium and various micronutrient deficiencies because of the high pH and bicarbonate levels it imposes. All tubewell water surveyed had high pH values — only 25 percent of 232 samples had a pH below 8 — as well as high bicarbonate values.

In contrast to normal and saline soils, sodic soils are typically hard to permeate and poor in tilth as a result of loss of structure and clay migration with the movement of sodic soil water. Using rough guidelines combining mean EC values and mean SAR values, sodicity hazards of irrigation water were surveyed in tubewells in head, middle and tail watercourse commands of Mananwala Distributary. Aggregate readings fell just within the borderline beyond which a permeability hazard is likely to arise. But water from 25 percent of tubewells in tail-reach watercourses had EC and SAR values already within the range of waters likely to cause permeability problems.

A rapid appraisal survey was mounted by IIMI in the command areas of 7 watercourses of the Mananwala Distributary in 1989, to record the presence of salinity — either as surface salting or obviously salt-affected crops — and of dense, hard subsurface layers. Those survey results also hint strongly at a general deterioration in soil conditions towards the tail of distributary canal commands due to secondary salinity.

Removal of salts from the crop root zone to maintain a salinity level compatible with the cropping system requires a downward flux of water and salts. Hence, water from rainfall and irrigation must be supplied to the crop, over and above the evapotranspiration needs, so that there is excess water to pass through and beyond the root zone and carry away salts. This excess water is usually referred to as the leaching requirement.

Computer modeling and simulation of water and salt balances permit an assessment of the effect of current farming practices on the build-up or removal of salts from the profile. We have used Hanks' model (a simulation model which weighs basic properties of soils and plants against weather and water-table conditions) to predict water and salt movement into and out of the root zone for three major crops grown in the command of the LCC system: cotton during kharif, wheat during rabi, and sugarcane over both seasons.

Simulations were done for both the median EC value and the 75 percent value (values exceeded by 25 percent of the samples) of irrigation water being pumped by tubewells and used by farmers in tail-end watercourse commands. Median irrigation applications for wheat grown in Mananwala Distributary command and for cotton and sugarcane grown in the command of Pir Mahal Distributary were used as input in the model.

Actual leaching fractions for wheat are sufficient to reduce profile salinity. For the other crops and for all soil textures tested with the model, profile salinity increased. The largest increase takes place in sugarcane grown on silt loam with irrigation water of 2.5 dS/m. Another important observation is that leaching is far more effective for wheat during the cooler rabi season than for crops grown during the hot kharif season, even though monsoon rainfall exceeds that from winter rains.

It does seem reasonable to assume that so long as the soil structure is not affected, the buildup of profile salinity is reversible. Reclamation should not take much longer than it took the salts to accumulate in the profile in the first place, except where clay migration has compacted the profile and cut hydraulic conductivity.

To sum up, measured and observed data confirm the existence of a disturbing pattern of increased salinity-related problems in Punjab's irrigated agriculture as location in surface irrigation systems varies with distance from the head of the distributary canal and the watercourse outlet. The primary source of salt accumulation is tubewell water of doubtful quality used by farmers for irrigation. Serious and persistent inequity in the distribution of high quality canal water within distributary commands, often mirrored at watercourse level, has meant that farmers in middle-and tail-reach locations increasingly depend on pumped groundwater to meet the bulk of their crop water requirements.

For reasons that are not yet well-understood, the quality of groundwater pumped by tubewells generally decreases between head and tail within distributary command areas. Thus, farmers in the tail areas face a double handicap: they receive less than their fair share of canal water compared to farmers upstream, and the groundwater supply they must therefore fall back on is of poorer quality than elsewhere.

True, farmers can successfully use water for irrigation that is more saline than that found in the command area of Mananwala and Pir Mahal distributaries. However, that would require mixing saline water with better quality canal water for irrigation, at least during germination and other sensitive crop growth stages, or changing production to more salt-tolerant crops such as fodder crops or agroforestry mixtures, or adopting some combination of these two.

In theory, mixing canal water and tubewell water for irrigation is a feasible alternative for farmers. But the problems faced by farmers and managers trying to achieve the right mix are daunting. Assuming no significant changes in current cropping patterns, management interventions with the objective of bringing the average EC value of the mixed irrigation water available to middle and tail watercourse commands below 1 dS/m, for example, seem certain to require greater quantities of canal water for mixing than are presently available at the locations featured in our study.

More and better management (in such forms, for instance, as selective canal maintenance) could much improve the current pattern of equity in distribution of canal water at the distributary level. However, present conditions of canal operations also reflect failure on the part of existing institutions to observe and enforce longstanding rules and procedures of irrigation system operations. That situation raises critical institutional issues that require careful investigation before a fuller range of appropriate management responses can be developed.

Still, it is hard to see how, in specific cases, even the most concerted of management interventions will provide a complete answer. For example, since the median EC value of tubewell water in the head reach of the Mananwala Distributary is less than 1 dS/m, farmers there could rely completely upon tubewell water to meet the needs of irrigated agriculture without changing their current crop mix or incurring secondary salinity problems. In such a hypothetical situation, all canal water then would be available for mixing in middle- and tail-reach watercourses. In order to produce an average EC water quality value of 1 dS/m for middle reach farmers, about 36 percent of the canal water now available would be required for mixing in. However the remaining 74 percent of canal supplies would, when mixed with the additional groundwater required to cover crop needs, still result in an average EC water quality value of only 1.23 dS/m for tail-reach farmers.

Thus, redistributing present canal supplies during peak consumption months would still not bring irrigation water quality to within acceptable limits throughout the entire canal command area, even were head-end farmers to use no canal water at all!

Selection of crop varieties for their salinity tolerance and changes in cropping patterns also seem certain to play important roles in sustaining agricultural production with poor quality irrigation water. So far, we are unaware of any systematic research in Pakistan focused on farmer response to effects of poor quality water and secondary salinity. Anecdotal field evidence does suggest that many Punjabi farmers are aware of the harmful effects of prolonged irrigation with poor quality tubewell water and already respond by changing their cropping patterns.

Whether or not a productive irrigated agriculture can be sustained through such changes is a subject that requires monitoring and continued evaluation of several dependent variables — including aquifer discharge and recharge, groundwater quality and canal-system performance. Collaborative research and development to strengthen existing institutional mechanisms for this purpose, remain an important component of IIMI's program in Pakistan.

IIMI APPOINTS DIRECTOR FOR RESEARCH

The International Irrigation Management Institute (IIMI) has recently appointed Mr. Khalid Mohtadullah to the newly created position of Director for Research.

A national of Pakistan, Mr. Mohtadullah brings to the Institute considerable experience and skill in water resource management. Previously, Mr. Mohtadullah was General Manager (Planning) of the Pakistan Water and Power Development Authority (WAPDA). Over a period spanning 30 years, he has occupied a variety of positions in the public water and irrigation sector in Pakistan, rising to high positions of leadership in his profession. Mohtadullah is an alumni of the Massachusetts Institute of Technology with a Master's Degree in Civil Engineering, which he received after completing his Bachelor's Degree at the University of Peshawar. He is also an alumni of the Harvard Business School, where he attended their Advanced Management Program.

The Director for Research is a new position at IIMI. It has been created to provide overall leadership to the Institute's worldwide research programs, particularly by directing thematic and global research programs and by advising on country-specific projects. The Director for Research will also provide strategic and program planning leadership for the Institute. This new post replaces that of Director for Programs.

NO STRANGER TO SALT

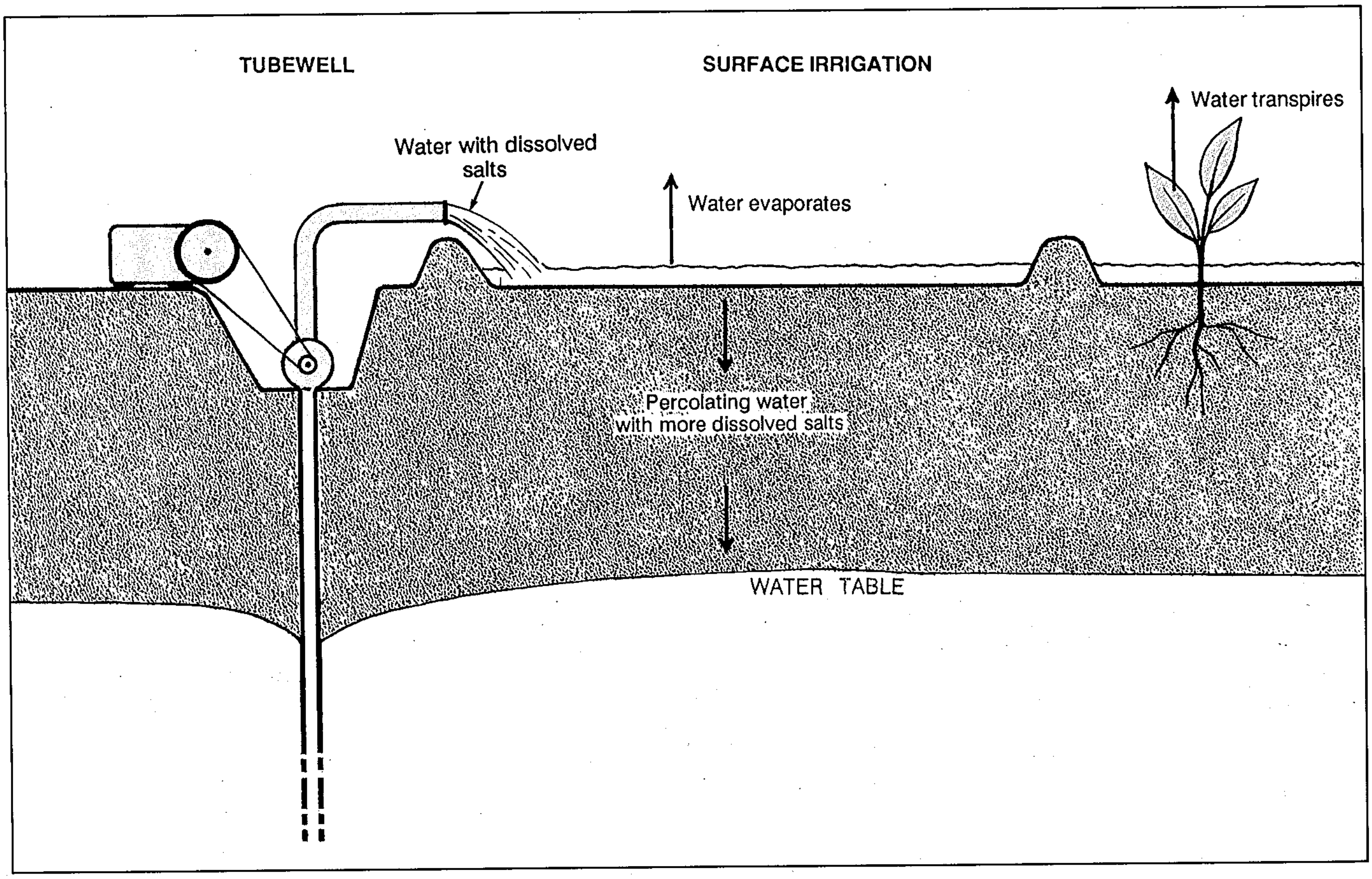
The Indus Basin is no stranger to salt. Most of the salinity that occurs there is ancient, produced as the result of soil-forming processes that followed the evaporation of the shallow sea that covered the Indus Plains and the Potwar Plateau 600 million years ago, leaving behind the twin salt ridges known as the Salt Range that transect the northern part of modern-day Punjab.

With the advent of modern canal irrigation, saline patches were recognized as occurring within good land in an intricate spatial pattern at the time systems were first being developed. Although larger saline tracts could be and were excluded from design canal command areas, the inclusion of smaller patches of salinity within areas of good soils was inevitable. Some were subsequently reclaimed; in other areas, reclamation attempts failed. The severity and extent of salinity problems became obvious by the middle of the present century, prompting the first Salinity Control and Reclamation Project (SCARP I), initiated in the central Rechna Doab in 1960, and later deep drainage tubewell projects.

Increased capillary action occasioned by the greater surface area and rate of evaporation in waterlogged land, was observed to be drawing growing increments of salt into the root zone of croplands. It seemed natural, therefore, to assume that with the reduction of waterlogging in large parts of the country, especially in Punjab, through extensive development and operation of tubewells, the problem of salinity should largely have been solved at the same time. But as early as 1978, surveyors warned that this was not the case.

Secondary salinity, which is of much greater concern than that akin to waterlogging, is the buildup of high sodicity in first-rate, nonsaline

(Continued on page 30)



Salinity buildup in cropland due to accelerated irrigation from low-quality water in shallow tubewells.

Book Reviews

14th Congress on Irrigation and Drainage Rio de Janeiro, Brazil 1990 Volumes 1 A-F (French and English)

A wealth of new materials stemming from the 14th Congress on Irrigation and Drainage has now become available from the 1990 meeting of the International Commission on Irrigation and Drainage in Rio de Janeiro.

In addition to the six books dealing with general reports and papers presented at the congress, there are three additional volumes (not a part of the congress papers) dealing with methodologies for information acquisition (French), a bibiliography on the influence of wind on sprinkler irrigation (French and English) and a publication dealing with guidelines on the construction of horizontal subsurface drainage systems (English).

One of the more interesting papers presented in the material is one written by Prof. Milos Holy, Czechoslovakia, dealing with man's influence on the environment. In it, Holy quite accurately emphasizes that " ... the environmental situation indicates that further development of the environment is becoming an essential question for the existence of the future generations of mankind."

Holy calls for "scientfic management and planning of life on Earth on a global scale," and also says that man's economic activities "must be developed in harmony with nature as only in this way can we guarantee the sustainable development of the present and future environment."

The cooperation demanded of men by Holy is all well and good in principle, but, unfortunately for Earth's sake, it will likely be a long time in coming on the scale necessary to satisfy Holy's call and therefore, the degradation of the Earth will likely continue to be news into the next century.

Matthew Driskill

PEEM GUIDELINES SERIES 1

Joint WHO/FAO/UNEP Panel of Experts on Environmental Management for Vector control - Guidelines for the Incorporation of Health Safeguards into Irrigation Projects through Intersectoral Cooperation; prepared by Dr. Mary Tiffen, Overseas Development Institute (ODI) Regent's Park, London.

The Panel of Experts on Environmental Management for Vector Control (PEEM) was established in 1981 as a joint activity of the World Health Organization, the Food and Agriculture Organization and the United Nations Environment Program. The panel's objective is to create an institutional framework for effective interagency and intersectoral collaboration by bringing together various organizations and institutions involved in health, water and land development and the protection of the environment, with a view to promoting the extended use of environmental management measures for disease vector control in development projects.

Publications in this series are aimed at giving technical guidance to a multidisciplinary audience whose responsibilities have an interface with vector-borne disease implications of development projects.

These guidelines are set out for policymakers, planners and managers who are themselves neither irrigation nor health specialists but who may wish to know of the impact of the project in terms of the targets envisaged within its economic framework, for irrigation projects are usually costly, and have to be carefully assessed to ensure that expected benefits will indeed flow and outweigh the costs.

This publication aims to alert planners and managers to the linkages between irrigation and health and the collaboration between government agencies needed to secure advantages of increased agricultural production and a better health status in a cost-effective way.

The Guidelines point out that

"A good irrigation scheme will provide greater security of water supply over a longer period of the year. It will enable farmers without risk, to invest in a higher level of inputs, so that they can produce a larger volume and/or more valuable crops, to the benefit of both themselves and their country. Amongst the human health benefits should be improved diets resulting from an increased production of staple foods, new opportunities of growing fruits and vegetables and increased purchasing power for foods not produced on the farm. Improved incomes should also positively affect health status by enabling people to spend more on clothing, housing, recreation and health.

"Other beneficial side-effects of irrigation can be new fishing areas, the possible development of recreation areas alongside reservoirs and canals, and better facilities for feeding and watering the domestic livestock which can also improve diet and income considerably."

The Guidelines state that " . . . However, we often find that health has either been ignored, or has been considered a separate item in the development of agricultural projects . . . irrigation leads to changes in the distribution of areas of standing and flowing water and in the location of human settlements, and to a modified micro-climate.

"It is worth stressing, however, that a major health hazard of some types of irrigation scheme is associated with the displacement of people from their homes and livelihoods, particularly in schemes involving the creation of reservoirs. The guidelines provide some information on integrated planning for these situations.

"Domestic water supply and improved sanitation can sometimes also be incorporated into irrigation planning, thereby bringing great health benefits through the access to improved water supplies for drinking and general cleanliness. Here, naturally, the quality of the water is of great importance."

B.H. Hemapriya.

FARMER PERSPECTIVES

Farmers and their families bear the brunt of problems of water supply in areas prone to secondary salinity. Many of the large distributary canals in Punjab run for 200 km or more without meeting a single gated structure. The individual farmer has to use a mix of regular and improvised means to secure enough water to raise a worthwhile crop. Interviewed beside their watercourses, two typical Punjabi farmers give their own accounts of the day-to-day consequences.

Habib's story

"My name is Habib — I'm 37 years old. My three brothers and I inherited this farm and we run it together. It's bigger than average for this area — a lot of land has been divided up between families till there's hardly enough in one plot to support a household. Ours is about 42 acres [17 hectares], mostly under wheat in winter, rice in summer plus sugarcane and fodder crops all year-round. It's part of a *chak* [watercourse command area] served by Sharkpur Distributary. The *mogha* [offtake] is supposed to serve 20 squares [about 500 acres] but apart from a few farms near the mogha where they use a *jalar* [traditional lift device] when the water runs low, nobody gets enough canal water and many get none at all.

Portrait of a Pakistan farmer.

"Things improved a lot when the Irrigation Department put in a tubewell 30 years ago. Then we had enough water to begin growing rice and sugarcane. But after working poorly for several years, this well broke down completely five years ago. Now we can't get it working again unless we collect money from ourselves, make some payments to irrigation staff and chase after the ID's maintenance gang to get them to repair the well. All the farmers in this chak organized two years ago to get the watercourse *pucca* [lined], but since that job was completed, the "committee" [water users' association] we formed never met again.

"When the government tubewell stopped working, we had to install our own tubewell to get enough water for the crops. This well has become very necessary now because canal water has also become less. But sometime after we began to use our tubewell to irrigate our crops much of the time, we noticed our yields were dropping back — the water from our tubewell isn't good for the soil unless you add gypsum. The agriculture extension people told us about using gypsum: we put a pile of the rocks under the tubewell discharge pipe and it definitely makes a difference to the crop. A truckload of rock gypsum lasts about two years, but it has become more and more costly; we just got a new load this month for 4,000 rupees [about US$170].

"But we still pay double *abiana* (water service fees) for public tubewell and canal water, even though we're not getting enough of one or the other. The fees are about 43 rupees for wheat, and 64 rupees for rice per acre. Many farmers cook the books so they pay more at the fodder rate of about 27 rupees and I can't say I blame them. Now and then they're caught out and of course the officials say this proves you can't trust farmers."

Khadim's story

"My name is Khadim: I'm 49. I support a family of seven and I share these 15 acres with my brother Boota, who has no family. Our fields used to be near the tail of the *sarkari khal* [watercourse] of the chak upstream [on Mananwala Distributary] but a group of us persuaded the Irrigation Department to install a new mogha just here. So now our fields are almost at the head of the watercourse instead of nearly two miles from canal water as we were before. We also installed our own tubewell, which we use mainly during the [annual] canal closure and at other times when canal water is less.

"This was ruined land till we got the new mogha. As you can see, there's still some salt on the surface in patches even though we've already scraped six inches of affected topsoil from these fields, which is in that pile over there. We're still in the process of reclaiming this land, even though it's hard to drain and we need a lot of water for this purpose.

"We didn't find it easy to get the new watercourse put in — it took three years of pushing. Now we've been asked why we don't improve the watercourse by putting in *pakanaka* [locally made turnout junctions] and so on, but I'm in no hurry — this close to the offtake, if the watercourse or the turnout breaks, I get more water!

"We reclaim the abandoned land by spreading powder gypsum on the field and soaking it through with fresh water. Then we grow salt-resistant fodder grass such as *kallar* for a season or two before we can grow such crops as rice. The official price of the gypsum is 8 rupees a bag but the dealers who hold permits to sell it say they haven't got any, so we buy it 'on the black' for 15 rupees.

"It takes roughly ten 50-kg bags of powdered gypsum a year over three years to reclaim a field of one or two acres, so it's not cheap. We don't have much faith in the official agencies. They don't seem to have much control over the water in the canals; why should we do their job for them? They look after themselves — but only God looks after the farmer!"

JACOB KIJNE IS APPOINTED DIRECTOR IIMI PAKISTAN

The Board of Governors of the International Irrigation Management Institute has appointed Dr. Jacob W. Kijne to the position of Director for Pakistan. Dr. Kijne, was previously Senior Irrigation Specialist in the Pakistan Division of IIMI.

Prior to his arrival in Pakistan, Dr. Kijne served in various leadership positions, including that of Principal of the National Agricultural College in Deventer, the Netherlands. He has also served as senior lecturer in Agriculture at the Department of Irrigation and Civil Engineering, Wageningen Agricultural University, the Netherlands, and was Acting Chairman and visiting senior lecturer in the Department of Agricultural Engineering at the University of Nairobi in Kenya from 1977 to 1981.

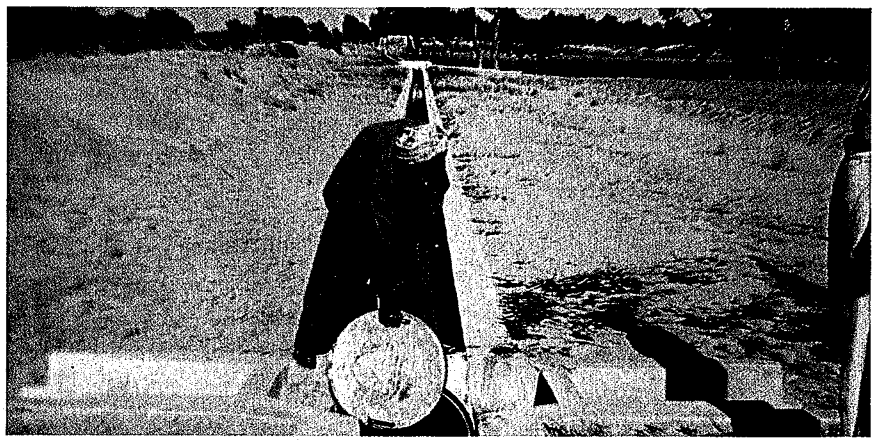
When asked about his new appointment, Jacob Kijne said that he expected the IIMI team in Pakistan to make timely and valuable contributions to irrigation management in the country. The recently resolved issue of apportionment of Indus water between the provinces and last year's Water Sector Investment Planning Study have caused renewed interest in the management of the irrigation system.

Commenting on Dr. Kijne's appointment at IIMI Headquarters in Colombo, the Institute's Director General, Dr. Roberto L. Lenton, said he was confident that Dr. Kijne's extensive research background, intimate knowledge of water and salinity management, and extensive managerial experience will serve IIMI exceptionally well.

FEEDBACK ON THE FARM

by M. Akhtar Bhatti

Irrigation conditions and practices at farm level truthfully reflect the operation of main systems. The farm is the "business end" of irrigation systems, where an intermediate output — water — is converted into a final output — agricultural production. Improving the performance of irrigation systems through management interventions at different levels, depends vitally on a two-way feedback of knowledge about the impact irrigation water has on agricultural production, and the efficiency of water use.



Locally manufactured turnout device ("pakanaka") – a boon to on-farm water management in many parts of Pakistan.

The operation of Pakistan's irrigation systems has long been administrative in character, concentrating on straightforward water delivery with scant concern for end use. The 40 years since modern Pakistan was founded have seen little change in management style despite significant changes in field realities. For instance, groundwater obtained from public and private tubewells has provided a fast-growing — albeit unevenly distributed — supplement to canal water. Cropping practices have altered and crop intensities have risen dramatically as a result of growing use of improved crop production technologies. High yielding crop varieties, mechanization and use of agrochemicals have all become part of the farming scene.

They have failed, however, to raise yields of most crops to anything like the potential realized elsewhere in Asia. Agencies in the water sector recognize that irrigation is a critical factor in the production equation and may well hold the key to this paradox.

Soon after its establishment in September 1986, IIMI Pakistan began seeking opportunities to put potential management (hence performance) improvements to the test at farm level in collaboration with home agencies, particularly provincial irrigation and agriculture departments. Several joint research activities were undertaken with these aims in view during 1987-90 in the Central Punjab. Most were carried out in collaboration with Punjab Irrigation and Agriculture departments in the head and tail portions of the Gugera Branch of the Lower Chenab Canal system. This work gave rise to several important preliminary findings.

Since the design and introduction of the *warabandi* (the practice of irrigation turns taken according to an established roster) system of water allocation, it appears no effort has been made to reassess historic water rights. Despite the major physical, political and socioeconomic upheavals of the past hundred years, allocation is still based on landholding. Comparison of agricultural census data from 1960 and 1980 shows that the number of small farms less than 3 hectares in extent increased from 34 percent of the total in 1960 to 51 percent 20 years later. Expressed as a fraction of total cultivated land, the area cropped on small farms also increased. Conversely, the fraction of medium and large farms within the total decreased significantly over the same period. Decrease in farm size directly affects water rights by governing the duration of the irrigation turn, which is set in proportion to land area.

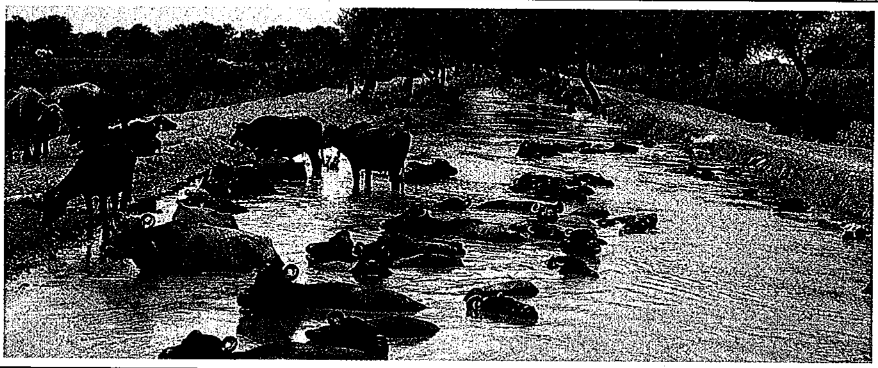
Much has been said about shortage of water resources in relation to crop water requirements, but little has been done to reevaluate allocation practices or to find ways and means to improve distribution procedures to match crop needs or cropping patterns. Sample data suggest that current management procedures preclude effective use of available irrigation supplies.

Flexible water allocation is rarely possible under the present warabandi system. In drawing up new rules for distribution and allocation of irrigation water, thought should be given to the growing quantities of water available to the farmer from tubewells, public and private. This trend is not confined to areas with good quality groundwater. Many private tubewells have also been installed in areas known to overlie saline groundwater. Here farmers tap or skim fresh (or marginal) groundwater from the aquifer using shallow wells.

Irrigation deliveries at the farm gate not only vary in quality and level from day to day but are also highly unreliable overall. In the case of wheat, prolonged canal closures for maintenance have proved specially detrimental to crop yields. Variability and unreliability appear to be key obstacles to improving water use efficiency on the farm.

In general, studies showed that the seasonal irrigation application falls short of the conventional requirement for maximum crop yield per unit area. A fortuitous result is higher-than-average yield *per unit of water*. The efficiency of Pakistan's farmers in this respect has been used to justify a rationale of "limited irrigation" (whereby irrigation system performance is judged mainly on the basis of yield per unit water) as the appropriate and realistic benchmark in water-scarce environments as in Pakistan. Wide dissemination of this concept will be required before further increase of productivity per unit of irrigation water can be achieved countrywide. Neither measurement sufficiently explains anomalies in the pattern of performance of different water sources. For instance, private tubewells, alone or in combination, offer greater water efficiency than public sources: farmers are perhaps more careful with their own resources than with public utilities. Notwithstanding lower frequencies of seasonal irrigation applications, the efficiency of individual applications was found to be quite low. Hence, it can be argued that improved irrigation practices could boost agricultural production without stretching the bounds of the present irrigation water supply. As irrigation applications are related to available stream size, improvements can only be made when a smaller range of sizes is made available.

Much variation was found in the sizes of basins prepared for wheat irrigation throughout the 7.5 million hectares annually planted in wheat in Pakistan. Marked variation occurred even within farms where soil, water



Damage to banks by wallowing buffalo is one of many on-farm factors that eat away at system efficiency and productivity.

Desilting a watercourse in Punjab.

supply and crop conditions were uniform. This anomaly not only results in waste of scarce irrigation water but also suppresses crop yields.

These conclusions have important management implications. For one thing, more reliable system operation has to be achieved before farmers can feel confident about making irrigation decisions that depend on availability of canal supplies. Evaluation of the stream sizes available on the farm is essential to determine their manageability: variable stream sizes can lead to significant operational losses. Improved management would require some standardization of stream sizes and corresponding re-sizing of present canal outlets. Sizes of stream issuing from tubewells should be considered in conjunctive management of canal water and groundwater. Efforts also have to be made to optimize stream and basin sizes under prevailing soil conditions to improve application and water use efficiency.

Pakistan's farmers, agency officials and policymakers agree that scarcity of irrigation water and present water use practices are the most critical constraints on growth in agricultural production. Given physical, financial and political impediments to development of new sources of water and water delivery systems, additional agricultural productivity must come primarily from more efficient use of existing water supplies.

Physical improvement of irrigation channels and watercourses can achieve significant water savings, yet the savings that can be achieved by farmers themselves through more efficient and productive use of available supplies are reckoned to be greater still. This switch of emphasis can only be brought about by improving farmer expertise: for this purpose, an efficient irrigation management extension service will be needed to demonstrate and popularize innovative on-farm water management techniques.

Finally, the anomalies discussed above underline the need for in-depth analysis of *interactions* between main system (in conjunction with tubewell) operations and on-farm management, with a view to improving the performance of both. Studies should focus on the twin questions of allocation of irrigation water over time and space and consequent impacts on agricultural production.

Akhtar Bhatti is Principal Irrigation Engineer in IIMI Pakistan.

SCHULZE RETIRES

Ernst Schulze retired as Director, IIMI Pakistan in June 1991. Ir. F. E. Schulze joined the IIMI staff in 1986. A graduate from the Wageningen Agricultural University, in the Netherlands, he worked extensively on water resources development, irrigation and drainage in a number of sub-Saharan African countries before becoming Director of the International Institute of Land Reclamation and Improvement (ILRI) in the Netherlands in 1972. In 1982 he was appointed Agricultural Counselor to the Royal Netherlands Embassy in Jakarta, Indonesia.

Schulze also served as Chairman of the Study Team commissioned by the CGIAR in 1981 whose report led to the establishment of IIMI. He became a member of IIMI's Board of Governors in 1983 and was Chairman of IIMI's Program Committee until his appointment to the IIMI staff.

(Continued from page 25)

agricultural land caused by irrigation with low-quality tubewell waters. This type of salinity was introduced with accelerated use of groundwater after about 1950, especially groundwater from shallow private tubewells. The first known private tubewell was started up near Lahore in 1938: by 1978 there were at least 21,000 in operation and today the number approaches 300,000 countrywide.

Symptoms of sodicity are hardening of topsoil, decrease in rate of infiltration and inadequate seed germination, especially of alkali-sensitive crops. This mode of salinization is treacherous, as it builds up gradually and farmers become aware of the problem only after the worst damage has been done. Apart from applications of gypsum (which conditions soils to remain open to infiltration) and the flushing through of fields with abundant fresh surface water, there is little the farmer can do about secondary salinization but delay its worst effects. The syndrome is now thought to affect more than a third of Pakistan's irrigated agriculture and — unless checked — could lead to the abandonment of fully 25 percent of the country's entire stock of cultivable land.

Part of the response of the Government of Pakistan to the problem of growing amounts of saline effluent from irrigated farms in the Indus Plains, is the massive Left Bank Outfall Drain. This billion-dollar project, presently around two-thirds completed, involves construction of a channel nearly 300 kilometers long to carry drainage water to the sea from networks of lesser drains meeting at a point near Nawabshah.

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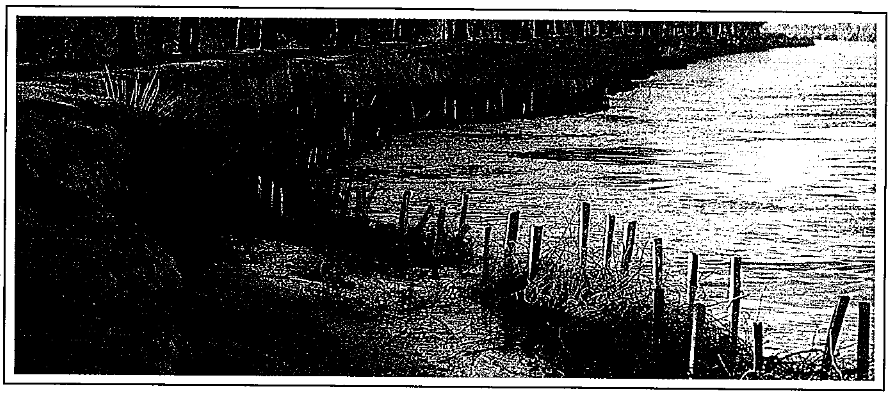


Makeshift repairs to breaches in canal banks – such signs of neglect are common in Pakistan's ageing systems.

Concrete lining, Takarwah Distributary, NWFP. All four provinces have ongoing OFWM programs.

UPSTREAM – DOWNSTREAM

Pakistan's irrigation infrastructure is massively concentrated in the nation's breadbasket, the central Indus Plains. Little wonder, then, that most irrigation research has been focused there to date.

But gradually the focus is shifting. Perception is growing among planners that the way water and land are managed in mountain areas far upstream, will have inevitable impacts on the big systems in the plains, just as the way the latter is run will in turn affect conditions downstream, most obviously in delta lands.

Awareness of the importance of these and similar linkages has spurred an influential lobby in federal circles for integrated management of the Indus Basin as a hydrological whole. This lobby is in some ways reinforced — in others complicated — by mounting pressure to afford outlying provinces a bigger slice of natural resources research and development finance, particularly where it relates to irrigation development.

Even within provinces where large-scale surface irrigation systems predominate, development of *barani* (rain-fed) lands is beginning to assume renewed importance and the rapid spread of private tubewells is proliferating informal systems of conjunctive use of groundwater and surface (and of 'public' and 'private') water.

These developments may bring more land under the plow and contribute to much-needed agricultural growth, or at least to the variety of means on hand to achieve it. But the fact that they often run at a tangent to measured development planning raises real anxieties, not least the fear of negative environmental impacts.

In the case of outlying regions where new federal investment is increasingly being injected to boost rural development, actions aimed at optimizing the use of water in agriculture that are not based on research tailored to local realities, can just as easily run the risk of counterproductive wrong turns. Knowledge gleaned from conditions in the 'textbook' systems of Punjab or Sindh, cannot be expected to fit predominantly traditional and smaller-scale systems in strikingly different terrains elsewhere.

IIMI has been working with various home institutions, initially mainly in Pakistan's mountain areas, to begin to help fill the research gaps. Some of the findings so far pinpoint special qualities of the systems under study which may well hold valuable general lessons, notably in the realm of farmer management and participation.

Irrigated agricuture occupies an estimated 400,000 ha of Pakistan's mountain lands. Though dispersed in small parcels and dwarfed by the more than 13 million hectares commanded by the Indus Basin systems, this total area is no smallholding and its location lends it obvious strategic importance.

Agriculture in the mountains and uplands of the Northern Areas, North-West Frontier Province and Northern Baluchistan presents a magpie pattern of water and land use approaches. A fairly constant feature is emphasis on communal management of the water resource. Irrigation systems are typically constructed and maintained through the collective efforts of farmers and villagers. They are often regulated by group ownership arrangements and by cooperative mechanisms for sharing and managing water with minimal conflict.

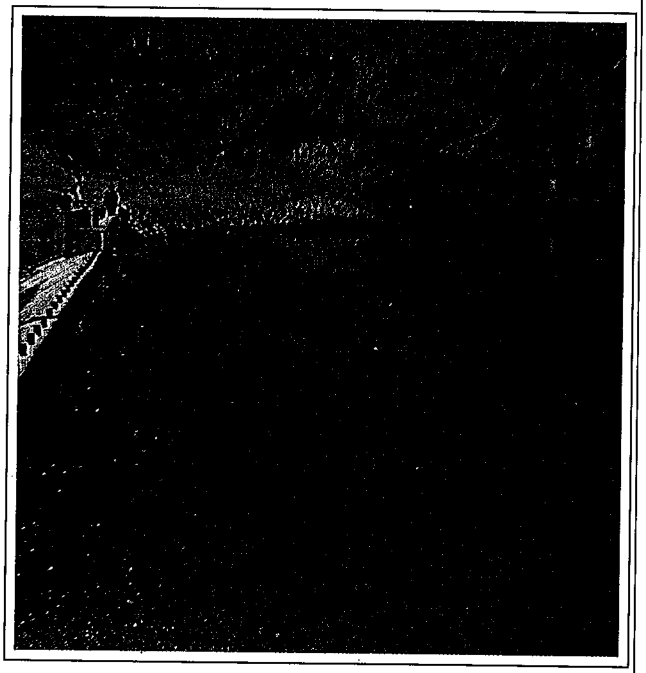
In the rugged Hindu Kush, Karakoram and Himalaya mountains, small channels or *kuhls* are used to carry water from mountain streams fed by springs or, more usually, by melting snow and ice. They serve watercourses that weave through clusters of (usually terraced) farms, orchards, wood and fodder lots and market gardens. Kuhl systems are a familiar feature of mountain agriculture not only in Pakistan but also throughout large areas of India and Nepal. Within Pakistan, published estimates suggest they command more than 48,800 hectares of the Northern Areas, with Gilgit District encompassing around a third of this total. Some 19,500 hectares of North-West Frontier Province, nearly all in Chitral District, are irrigated by kuhl or kindred systems.

At lower elevations, southwest of the Karakoram and Hindu Kush peaks, the terrain is interrupted by larger valleys drained by rivers like the Swat, Kabul and Kurram. Here annual rainfall dwindles significantly and bigger government-constructed canal systems such as the Upper Swat Canal and the Warsak Canal sustain the agricultural economy. Smaller 'civil canals' — older systems mainly farmer-built and farmer-managed but now maintained by public agencies — are also found there and in lesser valleys.

Further south into Baluchistan, where the mountains of Pakistan's western borders grade into increasingly arid plateaux, the indigenous *karez* systems of irrigation are found. Shafts are sunk in the alluvial fans, linked by galleries to form a tunnel that may tap a spring or, more commonly, collect subsoil water for delivery to fields lower down the gradient. Tubewell development is tending to supplant traditional karez practices in these areas.

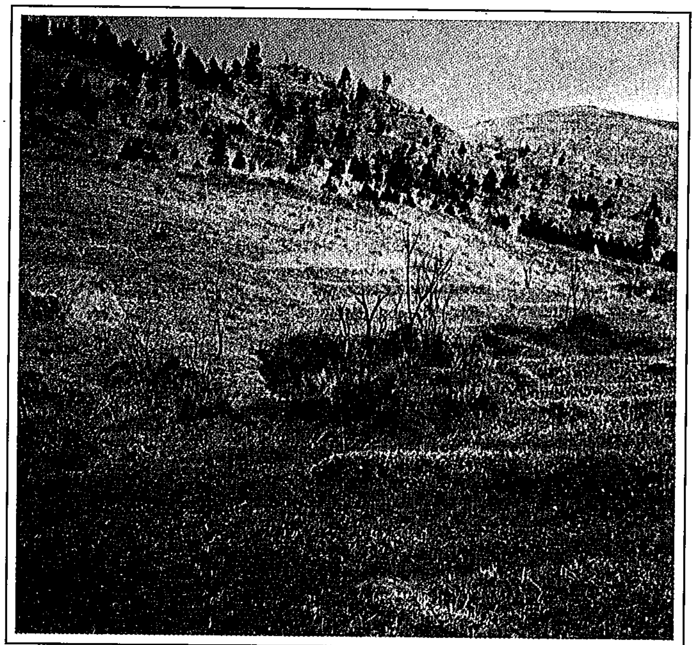
A 1989-IIMI report underlines a lack of sound knowledge of the real extent of irrigation systems in Pakistan's mountain areas, especially in relation to typology. The report calls for a systematic inventory of mountain irrigation systems that take account of system type and service area, using aerial surveys and remote sensing as shortcuts toward a comprehensive knowledge base.

Instancing case studies garnered from appraisals of irrigation systems under development in Gilgit District as part of the Aga Khan Rural Support Programme (AKRSP), the report also bears witness to "significant initiative and willingness on the part of farmers in this mountain region to improve or 'fine tune' their use efficiency and management of scarce water and land resources" and to the "resilience and flexibility of some traditional institutions in adapting to an environment of rapid social and economic change." Specific examples of management efficiency described in detail in the report include the pragmatic flexing of warabandi — the practice of irrigation turns taken according to an established roster — to cater (by common consent) to priority crop needs, even where this means overriding prearranged turns. Maintenance of the common portions of irrigation channels by farmers working in unison is another traditional feature that has kept systems efficient, though in some localities cash contributions to labor costs are often substituted for physical participation.



Small reservoir, northern Punjab.

Farmers showed great readiness to support and participate in AKRSP projects aimed at redesigning and restructuring old kuhl systems using modern system design criteria. These initiatives were based on careful surveys and measurements of system parameters such as bed slope conditions but also took pains to draw on the farmers' own experience and knowledge. Following installation of new systems, farmers also showed forbearance and improvisatory flair in dealing with hitches they recognized from experience as inevitable to the 'settling in' period any system must undergo in such a testing environment. Yet another example of adaptability to change cited in the report is the rapidly evolving role of the *chowkidar* — traditionally that of hired watchman but increasingly that of irrigation handyman, too.



Afforestation on an eroded hillside, Swat Valley, to protected irrigated wheatfields beneath.

From these and other detailed observations, the report concludes that "existing irrigation systems and farmers who manage them are a critical resource to be utilized in any effort to develop irrigation potential in Pakistan's mountain environments."

Also key to such efforts (says the report) will be studies not only of how farmers manage different kinds of systems in different areas, but also how well the systems perform, so that potential targets for improvement can be set on the strength of reliably observed facts and figures about such factors as water flows, irrigation efficiency, crop yields and institutional procedures.

The encouraging results of AKRSP initiatives in Gilgit inspired the Planning and Development Department of North-West Frontier Province to establish a similar program of assistance to FMIS in Chitral District in 1989, also in collaboration with AKRSP. Here, too, IIMI has played a part, refining appropriate rapid-assessment techniques that can be used by project managers to establish what new knowledge is needed for irrigation development, and training project staff to use them.

Plainly, the detailed study of mountain systems has far to go before it pays off in widespread management improvements and innovations. More fundamental knowledge of hydrological factors is equally wanting, as the federal Water and Power Development Authority (WAPDA) recognizes. According to the head of WAPDA's water planning directorate: "knowledge of basic supply factors that affect the whole basin, such as snow and ice hydrology or watershed management, is still in its infancy and we will need to change that in order to plan use on a quantitative basis."

The downstream situation deep in the south of Pakistan presents different problems but here, too, a need for new problem-solving knowledge is evident. The riverine lands of the Indus Delta are, no less than the mountain regions, the scene of distinctive traditional cultures. Multiple use of land and water — including agroforestry, seasonal fisheries and small-scale farming, using combinations of inundation and traditional lift systems for water capture — is the traditional pattern. But external factors press even harder here than in the highlands.

Karachi, Pakistan's biggest city, is also the fastest-growing conurbation in South Asia. Its population is presently on course to double within ten years, largely as a result of migration from rural areas not just in Pakistan but also in cross-border regions troubled by conflict. As it claims ever larger fractions of water and other natural resources, the city's needs increasingly overshadow those of indigenous delta and coastal cultures.

At the same time, there is a growing threat from upstream in the form of silt and saline effluent surpluses derived from irrigated agriculture along the Indus Basin's entire length. Remote sensing studies suggest that the delta's total area of mangrove swamps has been reduced by close to half over the past ten years, largely as a result of siltation. Salt invasion from the sea has also been blamed but this has probably already reached saturation point: today fears center on the giant Left Bank Outfall Drain (LBOD) now under construction. This billion-dollar project is designed to dispose of huge loads of saline effluent from the irrigated farms of Punjab and Sindh and will run from Nawabshah to the sea, a distance of nearly 300 kilometers.

Mangroves are generally regarded as brackish water plants but their survival requires a predominantly freshwater environment. Even discounting the additional salt loads that could spill or leak into the delta from the LBOD and other large drainage schemes that are expected to follow on its heels, the mangroves are struggling to contend with rising present-day saline effluent loads in the river. Their fate is closely linked to that of the traditional culture of riverine areas, for the mangroves are vital fishery breeding and feeding grounds as well as flood buffers, land stabilizers and sources of raw materials for village industry.

Pakistan's recently completed National Conservation Strategy includes a number of proposals for mangrove management and other conservation measures. The Strategy's authors are, however, repeatedly forced to the conclusion that more knowledge is needed that relates to irrigation practices upstream.

Researchers attached to USAID and other agencies have collaborated with provincial institutions in the past on a number of on-farm water management projects within Sindh, many of which have yielded promising results. IIMI has proposed collaborative projects in Sindh Province akin to those already underway in Punjab, with a view to extending the knowledge base necessary for improving system performance and limiting environmental risk throughout the basin.

Rain-fed agriculture at the fringe of the Indus Basin and beyond it, especially in Baluchistan Province, can perhaps justly be regarded as the Cinderella of water resource development in Pakistan. While management of irrigated and rain-fed agriculture are in many obvious respects separate enterprises, there are spin-offs, one from the other — notably in the realm of storage and pump technologies.

Though largely arid, Baluchistan would like to capture more of the some 25 billion cubic meters of water it loses each year through flash floods and divert it into productive sustainable agriculture. Provincial authorities would also like to see more investment in technologies such as hydro-ram pumps and sprinkler systems.

Yet, technological fixes cannot be expected to provide all the answers. The key to the future of barani agriculture in Pakistan may well lie in transferring not only new technologies but also modern resource management approaches, from the irrigated agriculture sector.

Robert Lamb

HAPPY ENDING TO WATER TALKS

Full agreement on allocation of Indus water to Pakistan's provinces was reached on 21 March 1991, by the Council of Common Interests. The news followed intense activity initiated by Finance Minister Sartaj Aziz and Prime Minister Nawaz Sharif, following repeated calls at the Water Sector Investment Planning Consultative Meeting held in Islamabad two weeks earlier for an end to the nation's long-running allocation disputes.

The accord provides for annual shareout of a total 117.35 million acre-feet (about 145 billion cubic meters) of the river supply between the four provinces, varying between summer (kharif) and winter (rabi) growing seasons. Sindh's share includes sanctioned urban and industrial use for metropolitan Karachi. No restrictions are placed on small schemes in mountain areas.

For any additional surface supplies, including storage releases, which may be harnessed in the future, the agreement lays down the provinces' percentage shares as: Punjab 37 percent, Sindh 37 percent, North-West Frontier Province 14 percent and Baluchistan 12 percent. These proportions broadly match the shares of present supplies allocated in the settlement. The agreement takes account of unpredictable variations in river flow; it does not, however, address the possibility of trade-offs of surplus water between provinces, or the groundwater factor.

Announcing the pact, the Prime Minister said agreement was unanimous and spelt an end to: "the most serious, sensitive and critical issue in Pakistan's modern history." He predicted that as a result of the breakthrough, agricultural production would surge over the coming five years. Some five million hectares of barani land would be opened up to cultivation, resulting in significant new opportunities for rural employment and social development as well as an estimated two million tonnes of extra wheat production. Development of the Kalabagh Dam scheme, stalled by earlier disputes, and of possible new schemes could now be reappraised, he added.

A few details remain to be settled. Allocations, based on a ten-daily cycle of irrigations, have yet to be worked out in close relation to agronomic requirements. The amount of water needed to be released below Kotri, the last barrage downstream, to check salt intrusion from the sea, will have to be quantified by expert studies. An Indus River System Authority is to be set up to regulate the agreement and head off potential future disputes. It will probably rule, too, on power generation, flood control and navigation concerns, but its powers and terms of reference have not been fully defined and will, in any case, probably require ratification by an Act of Parliament. At least two of the provinces are also considering setting up new bodies for post-Accord water resources development, to help make the most of their water shares.

IIMI fieldworker on a regular round of farm visits. Monitoring performance of irrigation systems by reference to their productivity means putting the farmer in the foreground.

Water Users' Associations and other village groups are there to minimize conflict and pool knowledge, no less than to spread the cost of physical improvements.

IIMI

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