# 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."

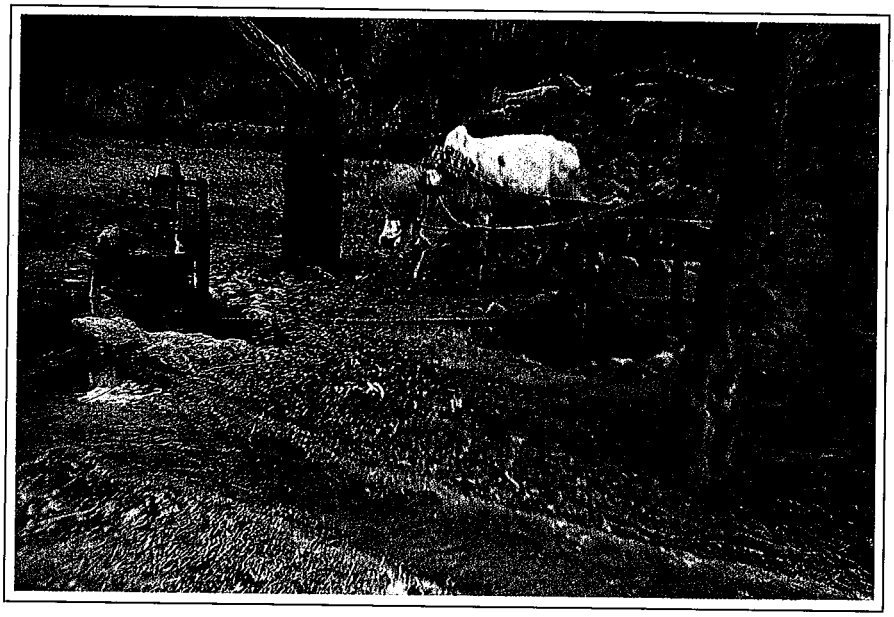
World Bank Director Michael H. Wiehen said most of the conclusions of the WSIP study were not new. Three earlier studies had offered similar diagnoses and national plans had followed their recommendations, yet a single acre-foot (1,231 cubic meters) of water in Pakistan's irrigated farms was now producing 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.

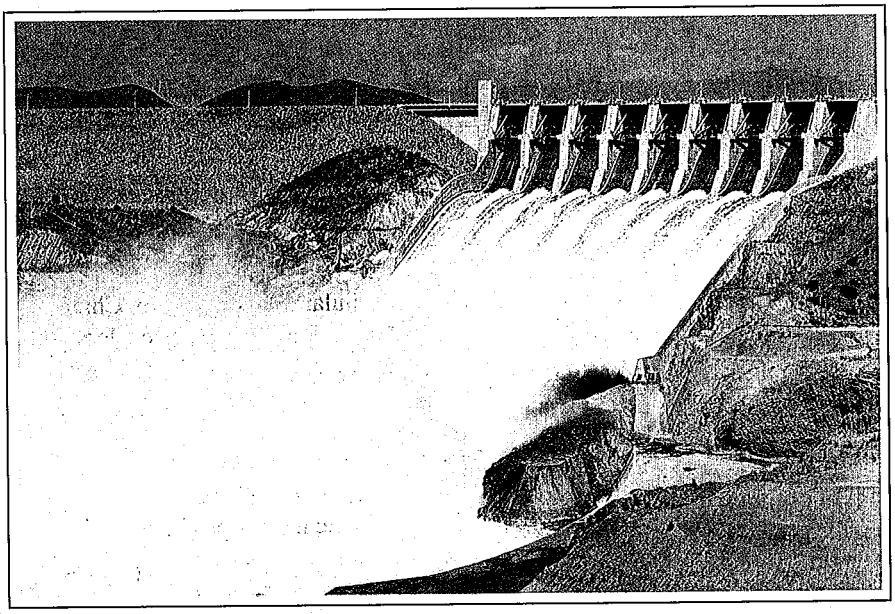
A working paper on Investment Planning Issues, by Dr. Richard H. Goldman, Harvard University, analyzed water sector investments cataloged in the WSIP study. Projects aimed at increased crop production (whether from growth in irrigated area, extra water or increased water delivery efficiency) formed 20 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)*

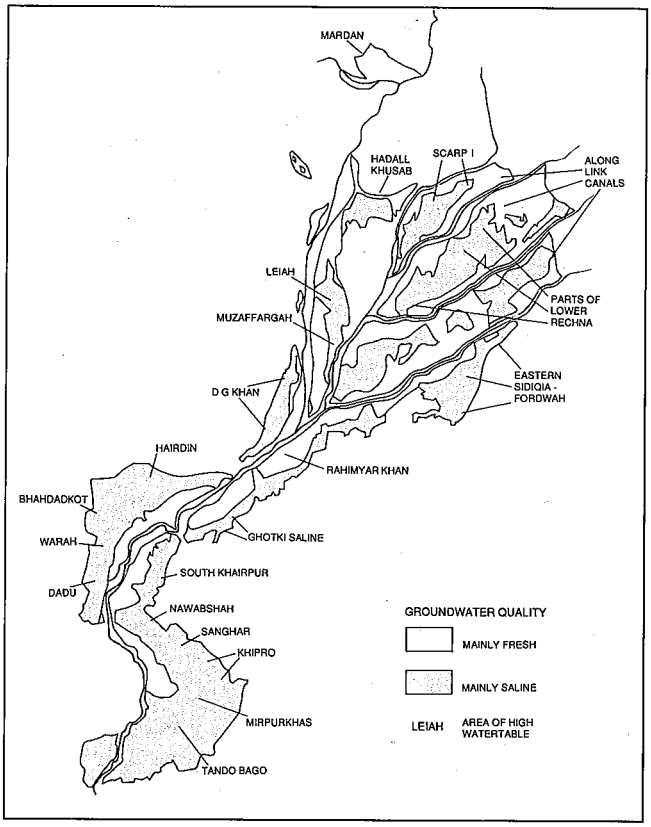
Pir Mahal distributary lies in a transition area between this rice-wheat region and the cotton-wheat agro-ecological zone further to the southwest. There, cotton is more frequently the main kharif crop, though wheat still predominates in rabi. In addition, sugarcane, various fodders, seasonal fruits, 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.

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.




*Saline groundwater areas and principal areas of high water table.*

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 distributary 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.