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# ANNUAL REPORT 1993

## International Irrigation Management Institute

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# ANNUAL REPORT 1993

## International Irrigation Management Institute

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# FOREWORD

In times when food is plentiful, it is difficult to entertain a sense of urgency regarding the world's future food supplies. Yet the stark facts remain: the current global population of 5.5 billion will double to 10 billion by the year 2050; the demand for food in developing countries is expected to increase by 150 percent over the next 30 years. Even at this relatively favorable moment in the cycle of supply and demand, many still go hungry. Today poverty continues to deprive an estimated 1 billion people across the world of a healthy and regular diet. By 2050 this number could be double or more.

Where will the additional food come from? And where will people find the additional income to buy it? An important part of the answer to both questions must come from irrigated agriculture. To meet the world's future demand for food, output from this sector will need to increase by 3.5 to 4 percent per year for at least the next quarter century; and to meet its potential for rural employment generation and livelihood enhancement, irrigation resources will need to be managed more effectively and equitably over space and time.

These improvements must be achieved in the face of a deepening crisis over both the availability and the quality of water. Water shortages already limit cultivation in many areas, as rising demand from domestic and industrial users competes with agriculture. Confrontations between countries over shared water resources are increasing in frequency and intensity. And the quality of water is deteriorating due to poor management, multiple use and excessive recycling, and pollution by agricultural chemicals.

In response irrigated agriculture must become more efficient, and most efficiency gains must come from better management. Globally, most irrigated areas are still producing at less than half their potential, and the area actually irrigated is frequently far less than that commanded. On many schemes, only one crop a year is grown instead of the two or three that would be possible if water were better managed. Water deliveries are usually supply-driven, and ill-matched to the needs of crops. They may often be unreliable and/or inequitable, with tail-enders or other underprivileged groups deprived of their fair share. On many schemes the over-or undersupply of water leads to problems of siltation, waterlogging and salinity, which severely depresses crop yields.

The need for irrigation management research and outreach to find solutions to these problems at the international level is, then, far greater now than it was when IIMI was founded in 1984. In responding to this increased need, IIMI is building on its achievements and impacts to date.

Management-oriented institutes always find it harder to demonstrate impact than technology-oriented ones. Often institutional in nature, their achievements—such as a change in the views of directors or policy makers—are not only more difficult to quantify but they may also sound less interesting than technological advances. In such cases impact is more easily conveyed in the spoken than in the written word.

Despite these handicaps, IIMI's recent External Program and Management Review has concluded that IIMI's impact to date has been real. Furthermore, more evidence of identifiable changes in operations and policies is being produced each year. This year's Annual Report describes several irrigation systems in which IIMI's presence is making a difference in operational terms. IIMI's impact on national policies is most evident in the countries where it has its two largest and longest established programs—Pakistan and Sri Lanka. In

Pakistan, the Institute's pioneering research on the problem of salinization has led to action at the highest levels of government. Following an exchange of letters with IIMI, the Prime Minister has established an interministerial committee to decide what should be done to combat salinization and ensure action by the relevant agencies. Meanwhile, research on canal maintenance has led to a decision to reexamine the desirability of canal lining, which IIMI's research has shown is often uneconomic in the present institutional and policy context. In Sri Lanka, IIMI's policy impact continues to be felt. The country is now firmly committed to a participatory approach to irrigation management and IIMI is continuing its long-term assistance in developing, evaluating, and refining this policy. On a major new irrigation scheme, IIMI has helped create a framework for deciding on the sharing of water under conditions of scarcity fraught with the risk of conflict. On several other systems, IIMI is helping the Irrigation Department introduce computerized tools for improved decision making, an area in which strategic research has helped to define the conditions of successful intervention, improving the future prospects of impact still further.

In other countries, there is mounting evidence of the respect with which the Institute's voice is heard by a growing number of managers and policy makers across the developing world. By way of example, the Government of Nepal has invited IIMI to participate in formulating a 25-year National Agricultural Perspective Plan. Last year also saw the completion of important studies on Sudan's Gezira Scheme, where a major overhaul of tertiary level management is now under way. In Nigeria, the successful development of water users' associations in a large irrigation system has led to rapid and tangible improvements in the physical condition of watercourses—and to the more widespread adoption of the approach used to develop the associations.

Many of IIMI's institutional achievements consist of breaking down barriers between sectors. In Sri Lanka, the Institute has led the design of a novel project on the shared control of natural resources within watersheds. This project is an exciting one in two ways. First, it is based on full acceptance from the outset that land and water resources have multiple uses, and that only by bringing the various interest groups together can a more productive, equitable and sustainable use of resources evolve. Second, IIMI has taken a participatory approach to project design and implementation, in which users' views are incorporated alongside those of professionals and conflicting interests are openly discussed.

Other examples of IIMI's impact at the national level are given in the pages which follow. Although we have chosen to present only a selection of the Institute's work during the year, we hope our selection finds favor. To us, these examples provide ample evidence that IIMI is doing its job with the commitment and the concern for quality that are the hallmarks of a center of excellence within the Consultative Group on International Agricultural Research.

Roberto L. Lenton

**Roberto Lenton**
*Director General*

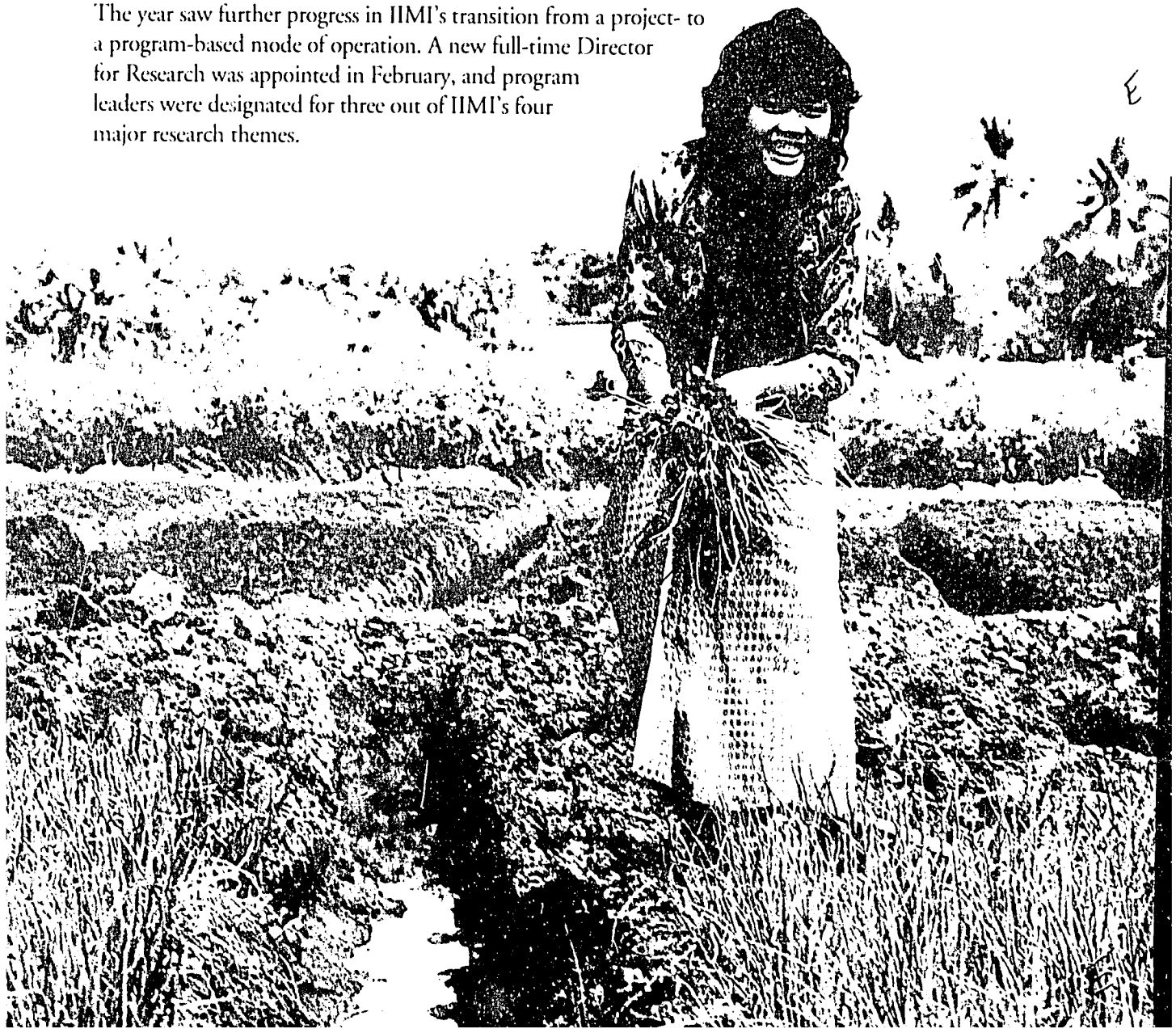
D

# IIMI's Research Results 1993

This year's Annual Report, like the last, presents a selection of the results of IIMI's work. The first section focuses on programs of thematic research carried out by the Institute during the year. The Country Programs section describes IIMI's in-country collaborative research with national programs conducted in several developing countries. More detailed accounts of the results of the Institute's work can be obtained from IIMI's publications or from the papers published externally by IIMI and national scientists. These are listed in Annex II.

The five major thematic headings under which we report this year are Sustainable Management of Water Delivery and Disposal, Performance Assessment and Improvement, Improving Public Irrigation Organizations and Sector-Level Management of Irrigated Agriculture (these two programs are reported on jointly because they came under the purview of one Program Leader), and Local Management of Irrigation. Three further themes are defined as crosscutting, being closely interwoven with all the programmatic themes although they may have an intellectual "home" in one of them. These crosscutting themes are Environment and Health, the Choice and Use of Technology, and Gender Issues.

The year saw further progress in IIMI's transition from a project- to a program-based mode of operation. A new full-time Director for Research was appointed in February, and program leaders were designated for three out of IIMI's four major research themes.



# THEME 1: SUSTAINABLE MANAGEMENT OF WATER DELIVERY AND DISPOSAL

## INTRODUCTION

By managing the core business of water delivery and disposal more efficiently, many irrigation agencies could markedly increase the productivity of the systems under their care. They could also improve the equity with which they deliver water to users. And they could attenuate two of the major environmental problems afflicting irrigated agriculture—salinization and waterlogging.

In many irrigation systems, improved water deliveries could be introduced without delay and at little extra cost, since the key factors preventing improvement are managerial rather than technical. Ensuring sufficient and reliable water deliveries to farmers is often a prerequisite for other improvements in system performance, so the benefits of improvements in this area would be high.

Much of IIMI's field work during 1993 related directly or indirectly to the central theme of water delivery and disposal. This year we highlight three major topics. The first is the problem of water allocation under conditions of scarcity—a glimpse into the future for many irrigation systems as demand from other sectors intensifies. The second is how to improve the efficiency of Sudan's Gezira Scheme, a question of central importance to that country's beleaguered economy. Third, we report the latest findings in IIMI's study on the vexed issue of soil salinity in Pakistan. This study has its "home" under the water delivery and disposal theme but also forms part of IIMI's crosscutting theme on environmental and human health issues.

Also reported under this theme are some of IIMI's studies on computer applications to support decision making in irrigation systems. Many managers at present have little rational basis for the decisions they make on system operation and maintenance. Typically, they either rely on past procedures, or else find themselves at the beck and call of whatever pressure group that exerts the strongest (or the most recent) influence. In 1993, IIMI conducted an important strategic study to assess the impact of interventions in this critical area. It outlined the principles of effective intervention, and studied these principles at work in two irrigation systems.

## FIELD STUDIES

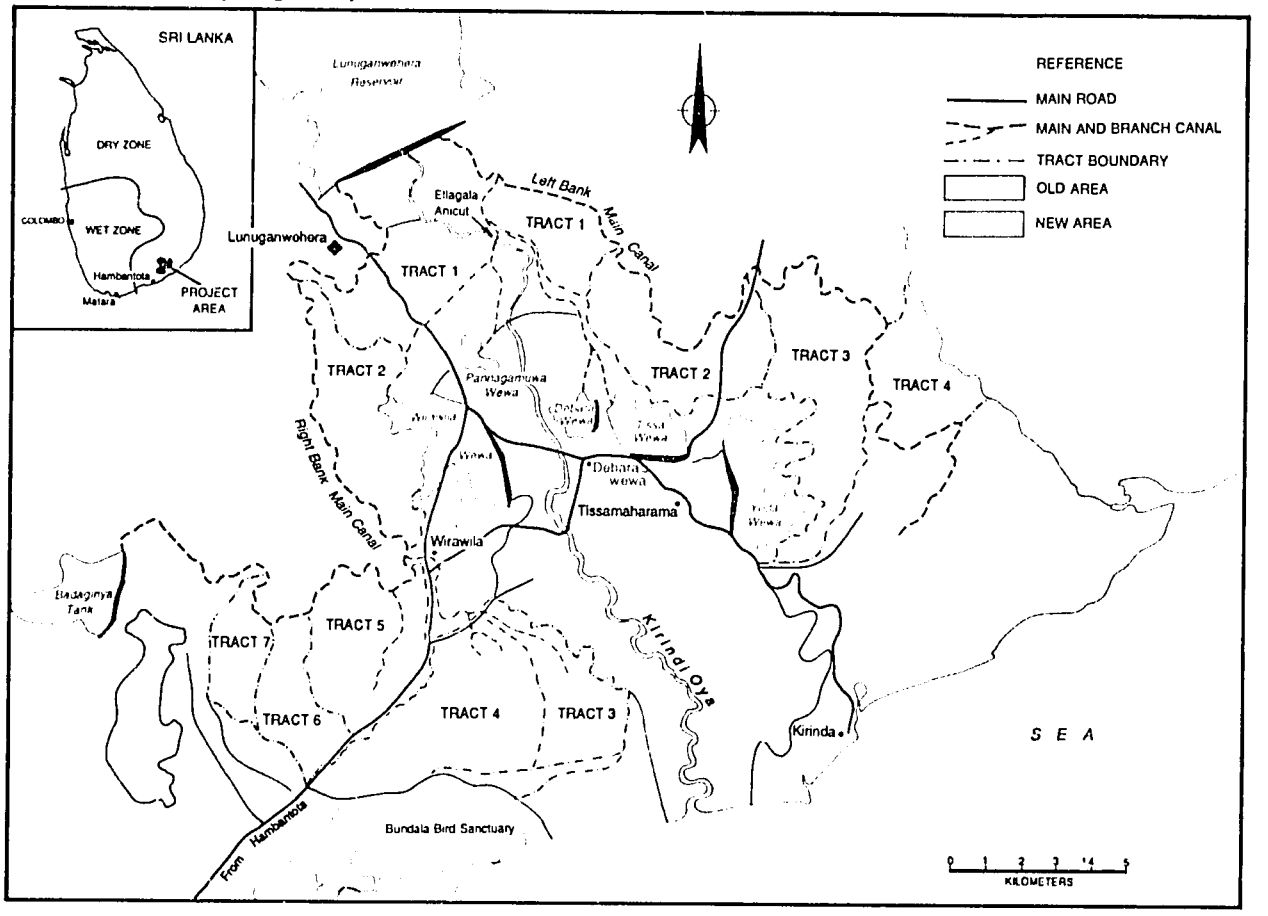
### Dealing with Water Scarcity: The Case of Kirindi Oya

When water is scarce, three essential ingredients of the water allocation process can help to prevent or at least mitigate conflict:

- Data on supply and demand that are publicly accepted as objective and accurate.
- Publicly recognized principles for deciding who should receive water under different supply and demand scenarios.
- A person or body authorized to make allocation decisions and having the stature (or clout) in the community to make those decisions stick.

The case of Sri Lanka's Kirindi Oya System is a classic illustration of the importance of these ingredients. The system falls within the bimodal rainfall area of dry south-eastern Sri Lanka, where there are two cropping seasons: the *maha* season, from October to February, and the *yala* season, from April to August (see Figure 1 and Box on page 2).

*Figure 1. The Kirindi Oya Irrigation System.*




## KIRINDI OYA: A RECIPE FOR TROUBLE

The core of the Kirindi Oya System is the preexisting Ellegala System, inhabited by farmers with a long tradition in irrigated rice production. The Ellegala diversion from the Kirindi Oya, which irrigates some 4,050 hectares (ha), was originally constructed to bring water to five ancient and previously independent tanks.

Plans to expand this system were formulated in the 1970s and implemented in the 1980s. The basis for expansion was the construction of the new Lunugamvehera Reservoir, damming the Kirindi Oya upstream from the Ellegala diversion. In theory, this would allow over 8,100 ha of new land to be brought under irrigation. The land, which was to be subdivided into seven tracts on the right bank and four on the left, would be irrigated by two new main canals issuing directly from the new reservoir. About 8,000 farmers were to be settled on this land, most of them from other parts of the country. In addition, the Right Bank main canal was to be extended so that water could be brought to the 800-ha Badagiriya System located outside the Kirindi Oya Basin. Diversification away from rice into other crops would help the additional water supplies go further.

Phase 1 of the project—the reservoir and the two main canals and portions of the new settlement area—was completed in 1986, but most of the construction envisaged under phase 2 was abandoned and the new land irrigated amounted to only 5,265 ha. The reason was simple: during planning, water availability had been overestimated by at least 30 percent. The initial appraisal put average annual inflow to the reservoir at 392

million cubic meters. A restudy carried out in 1986 gave a figure of only 314 million cubic meters. In fact, inflow since 1986 has been significantly less even than this revised figure. This planning fiasco made conflict among farmers almost inevitable.

Because they were the traditional users, farmers in the Ellegala System claimed priority in the allocation of water over users in the new areas—a claim that many agency officers at first accepted. The new settlers were not well organized and many of them were unfamiliar with irrigated agriculture, making them less able to defend their interests.

Table 1 shows the areas irrigated for all seasons from yala 1986 to yala 1993. Until 1992, the Ellegala farmers have emerged as the main beneficiaries of the new construction, having experienced irrigation of virtually 100 percent of their area in every season except two. The two exceptions—maha 1986/87 and yala 1987—were seasons of severe drought. In contrast, new areas had few seasons in which a high proportion of the land was irrigated. During maha 1986/87, many settlers lost their crops when the reservoir ran dry.

The new scheme has, then, failed to provide a livelihood to its intended beneficiaries. Many of these have abandoned their allotments or rented them out. Others live elsewhere and come to work their land only when irrigation water is being issued.

In 1986, two separate Project Management Committees, one for Ellegala and one for the new areas, were set up. In 1990, these were merged, forming a single forum at which to discuss water allocations. This strengthened the voice of the settlers in the negotiating process. In addition, agency officers were becoming more sympathetic to the settlers' appeals for a fairer share of the water.

Matters came to a head in April and May 1992, when the extra demand for water caused by cultivation of a late maha crop in the new areas coincided with an unusually dry yala season (see Box ).

## YALA 1992: DISASTER IN ELLEGALA

When the single Project Management Committee was formed, Ellegala farmers at first boycotted its meetings, suspecting that it meant to curtail the priority access to water they had enjoyed so far. Their suspicions were confirmed when the committee decided to authorize late rice cultivation for the maha season in tracts 2 and 5 of the Right Bank's new areas. Cultivation would extend into May, depriving Ellegala farmers of part of the water for their yala crop.

When the committee met March, irrigation from a single tank in the Ellegala System had already started. At the meeting, the Irrigation Department's engineer pointed out that the water level in Lunugamvehera was too low to allow cultivation of the whole of Ellegala. An argument arose over just how much water was available. The meeting ended with a decision to allow one further tank to irrigate, but to postpone decisions on the rest until the rains had set in.

*Table 1. Areas cropped in Kirindi Oya, 1986–93 (in ha).*

| Season | New areas | | | Ellegala | | | Total |
|---|---|---|---|---|---|---|---|
| | Paddy | Other crops | Total | Paddy | Other crops | Total | |
| Yala 86 | 1,012 | 0 | 1,012 | 4,293 | 0 | 4,293 | 5,305 |
| Maha 86/87 | 648 | 0 | 648 | 3,402 | 0 | 3,402 | 4,050 |
| Yala 87 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Maha 87/88 | 4,293 | 0 | 4,293 | 4,050 | 0 | 4,050 | 8,343 |
| Yala 88 | 2,430 | 0 | 2,430 | 4,050 | 0 | 4,050 | 6,480 |
| Maha 88/89 | 4,293 | 0 | 4,293 | 4,050 | 0 | 4,050 | 8,343 |
| Yala 89 | 1,903 | 0 | 1,903 | 4,050 | 0 | 4,050 | 5,953 |
| Maha 89/90 | 2,430 | 0 | 2,430 | 4,050 | 0 | 4,050 | 6,480 |
| Yala 90 | 0 | 324 | 324 | 4,050 | 0 | 4,050 | 4,374 |
| Maha 90/91 | 4,293 | 607 | 4,900 | 4,050 | 0 | 4,050 | 8,950 |
| Yala 91 | 0 | 389 | 389 | 4,050 | 0 | 4,050 | 4,439 |
| Maha 91/92 | 5,062 | 162 | 5,224 | 4,050 | 0 | 4,050 | 9,274 |
| Yala 92 | 0 | 0 | 0 | 101 | 0 | 101 | 101 |
| Maha 92/93 | 4,293 | 0 | 4,293 | 4,050 | 0 | 4,050 | 8,343 |
| Yala 93 | 0 | 81 | 81 | 1,620 | 810 | 2,430 | 2,511 |

Another meeting was held in late April. Irrigation Department officers explained that there would be a shortage even if only the areas in which cultivation had already begun were irrigated. Given the poor season, the officers counseled caution in relying on late rainfall. Despite this warning, the Ellegala farmers demanded water allocations for rice for the remaining Ellegala areas. The committee resisted this demand, deciding to wait until more rain had fallen.

This decision was unsatisfactory to the Ellegala farmers, who organized a demonstration in protest. In response, on 1 May, a further meeting was held, at which the officers again explained that there was not enough water and that it was unlikely that enough rain would fall in the late season to make up the deficit. However, the farmers demanded, and this time got, water issues for the whole of Ellegala.

At the request of the Irrigation Department, meetings with farmers were held in areas where cultivation had not already begun, to warn against the risks of harvest loss. But cultivation went ahead, with some farmers' representatives encouraging farmers to cultivate so as to maijtain their priority rights to the water.

As the season progressed it became clear that the worst fears of the agency staff were being realized. Rains were lighter than usual and failed altogether in mid-June. Water issues stopped on 2 July, when the level in Lunugamvehera fell 2 feet below the minimum operating level. This stoppage was necessary to protect domestic water supplies to the new areas. Ellegala farmers protested to the State Minister for Irrigation. As a result, another 1,215 hectare-feet of water was released, but the Irrigation Department stopped releases for good on 23 July.

The result was total crop failure in all parts of Ellegala except for the command areas of the two tanks where cultivation had begun early. About three-quarters of the total Ellegala crop was lost.

But the worst was still to come. During the 1992/93 maha season, the allocation process broke down altogether, leading to open conflict (see Box ).

### 1992/93 MAHA: OPEN CONFLICT

Under the allocations announced by the Project Management Committee in late July 1992, only a third of the new areas was to receive sufficient water to cultivate a rice crop. A wave of unrest in the new areas followed the announcement. A final meeting of the committee on 19 November failed to satisfy farmers in Left Bank tracts 1 and 2 and Right Bank tract 1. An independent farmers' organization was formed, and a delegation of farmers took the problem to the Minister of Lands, Irrigation and Mahaweli Development. The Minister agreed to issue water for rice on 20 December provided that all plowing be completed by that date using rainfall only.

When Irrigation Department employees tried to deliver water on this basis, they were threatened by angry farmers, who had heard that the Minister had ruled that water for rice should be made available to all. Left Bank farmers cut the cables controlling the gate to the Ellegala feeder canal, blocking water deliveries to the old scheme so as to obtain more for their own tracts.

On 25 December, a new delegation of farmers met the Minister, who ordered that sufficient water for rice be released to all parts of the three tracts from 27 December. One consequence of this decision was the loss of the nonrice crops that had already been planted over at least 260 ha. In many cases, these crops were simply plowed under. Many of the farmers who planted them are now claiming compensation from the government.

In the end, the maha rice crop turned out well throughout Kirindi Oya. However, the season extended into May, once again requiring the use of yala inflow to the reservoir and so constraining the production of the yala crop in Ellegala. In other words, farmers in the new areas had obtained a rice crop at the expense of part of the Ellegala crop for the following season.

The breakdown of the allocation process was characterized by disagreement on each of the three vital ingredients of an allocation system mentioned above.

*Sufficient and reliable water deliveries to farmers will facilitate other improvements to system performance.*

Disagreement over water supplies centered not on the level of water in the reservoir, which was known, but on its interpretation. Officers refused to count water below the minimum operating level as available for irrigation, since its equitable delivery to farmers could not be guaranteed and in any case this water was reserved for domestic supplies to the new areas. In general, they adopted a more conservative position than farmers, since this allowed them some leeway if late rains failed or inflows were overestimated. On the demand side, there was uncertainty over the amount of land planted to crops other than rice.

The most obvious case of disagreement over the principles of allocation was the claim by Ellegala farmers to absolute priority and the rejection of that claim by new area farmers and, increasingly, by agency officials. A more subtle source of disagreement concerned who should grow nonrice crops, which demand less water. Government and agency intentions to promote diversification, which had been written in to the original expansion plan for Kirindi Oya, continue to be thwarted by farmers, who perceive rice as a relatively risk-free crop compared to other cash crops. In addition, landlords demand that tenant farmers grow rice, since there is no legal provision for rents on other crops.

The Project Management Committee is recognized as the legitimate decision-making body, but its lack of a legal status leads to circumvention. All parties made use of alternative decision makers when the committee failed to reach a decision in their favor.

Under these difficult conditions IIMI has been working with agency officials in an attempt to improve the water allocation process.

The Institute's final report on phase 1 of the project had led to the appointment of a special task force to investigate the issues surrounding water allocations. The task force in turn appointed a subcommittee to propose a new approach.

The subcommittee put its proposals to farmers at a meeting in May 1992. The basic principle was that of rotation, with different portions of the system receiving water for rice or nonrice crops each season. Farmers rejected this approach, presenting instead a set of recommendations aimed at making it possible to cultivate the whole of Kirindi Oya every season. Their proposals, which included a switch to banana for part of the scheme, reflected a degree of wishful thinking regarding water supplies.

In June 1992, a new Technical Committee was formed, consisting of IIMI and local agency officials. This committee began by reexamining the inflow data for the reservoir. Inflow levels for three different types of season were specified: a dry maha, a wet maha and a normal yala. The committee also sat about refining estimates of demand, based on three types of crop: rice, other irrigated crops, and rain-fed crops receiving only supplemental irrigation. In this

way, it was hoped to improve the information base for decision making on allocations.

The improved data on supply and demand became the basis for allocations for the 1992/93 maha season, which revisited the rotation idea proposed earlier. Events during this season led the committee to revise its proposals yet again. The outcome is a complex set of rules that seeks to respond to the season as it unfolds, while striking a fair balance between the interests of the two groups of farmers (see Box below).

### ROTATION: THE NEW RULES

The committee proposed that:

- The new area (except for Left Bank tract 3) should be divided into three zones of about 1,620 ha each, one on the Left Bank and two on the right. During maha, two out of three zones would receive water for rice and the third for rain-fed crops. The area designated for rain-fed crops would rotate among the three zones. If, by the end of December, the maha season was judged to be a wet one, the area designated for rain-fed crops would receive water for a late rice crop following the harvest of the rain-fed crop. If the maha season proved dry, the rain-fed crop zone would receive water for a nonrice crop during the following yala season. The areas designated for rice would receive no water during the following yala.
- Ellegala would receive water for 100 percent rice cropping during maha, and for 70 percent rice and 30 percent other irrigated crops during yala.
- Badagiriya would receive 2,025 hectare-feet of water during maha and nothing during yala.
- Tract 3 on the Left Bank would receive water for nonrice irrigated crops during both maha and yala. This is an area specially designated for nonrice crops under the original expansion proposal.

The key point is that some of the yala inflow to the reservoir would be used to grow the late maha rice crop authorized for the third new zone. This sanctions the allocation of maha 1992/93, by which Ellegala was the loser.

It remains to be seen whether these rules will work, and whether they will be accepted by the powerful Ellegala farmers, who stand to lose their traditional exclusive rights to the Kirindi Oya's scarce water supplies.

Despite or rather because of the conflicts, the past few seasons at Kirindi Oya have taught important lessons to farmers, agency officers and politicians (see Box below).

### LESSONS LEARNED

The farmers of Ellegala learned that they should not distrust Irrigation Department data on water availability, and that it is unwise to disregard warnings of crop failure. One result of the disastrous yala 1992 season was a massive change in the leadership of farmers' organizations. New-area farmers learned not only to be more vociferous in demanding water, but also that working outside the legitimate committee structure causes conflicts among themselves. By ignoring agency recommendations, both sets of farmers tested the limits of their powers in the emerging context of participatory management.

Agency officers learned that they must communicate the reasons for their recommendations better. Farmers are unwilling to accept decisions which adversely affect their interests unless they have a good grasp of the alternative demands for water placed on the system and of the consequences of a breakdown in the accepted allocation process.

The politicians directly involved learned not to listen to only one interest group, and to be more cautious in overturning the decisions made by the legitimate authority, the Project Management Committee.

## Improving the Efficiency of Sudan's Gezira Scheme

Two major studies on Sudan's Gezira Scheme were completed in 1993. The first, based on data collected by HR Wallingford, investigated agency management of water deliveries at major and minor canal level, the second investigated farmers' irrigation practices and their impact on crop production. The latter study reflects IIMI's increased emphasis on the performance of irrigated agriculture rather than that of the irrigation system alone.

Lying close to the confluence of the White and Blue Niles south of Khartoum the Gezira is one of the world's largest irrigation schemes. Improving its performance could have a significant impact on Sudan's economic growth (see Box).

### THE ECONOMIC CONTEXT

The major crops of the Gezira Scheme are cotton and wheat. Except for cotton picking, which is still done manually, all operations are mechanized. During the 1980s, the area cultivated to wheat rose sharply in response to government policies to increase irrigated cereal production, displacing cotton to rain-fed areas (see Figure 2). By the mid-1990s the area of wheat is expected to reach 300,000 ha.

Despite this rapid expansion, yields of wheat are highly erratic. While on an upward trend, they remain, at 0.5–2.3 tonnes per ha, well short of the potential under irrigation. The fluctuation is somewhat less in cotton but still significant, and yields of cotton have tended to stand still in recent years (see Figure 3 on page 8).

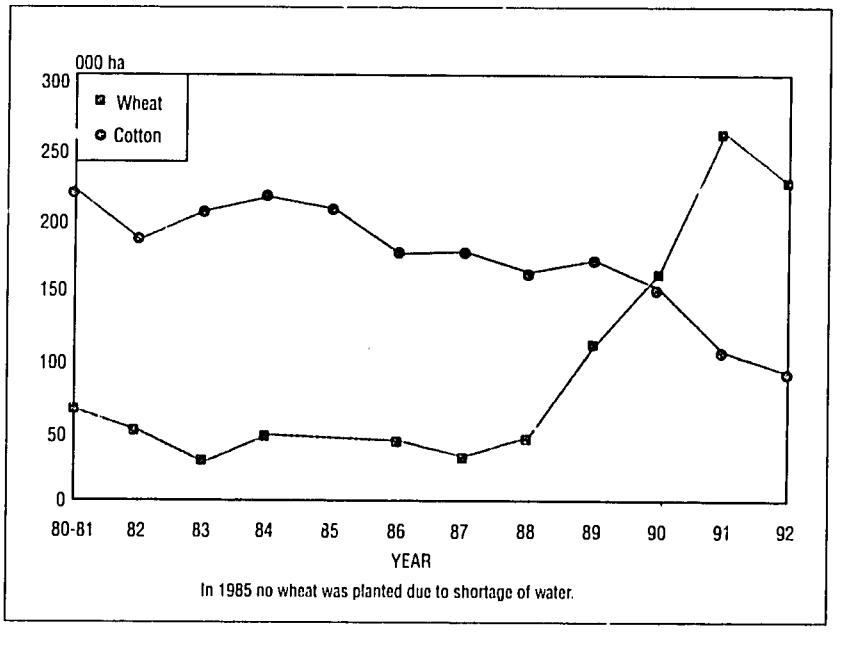
The government has recently deregulated the production of wheat, allowing its sale on the open market and the provision of inputs and services by the private sector. Cotton, however, remains a state crop, earning its growers, who are paid at the official conversion rate for foreign currency, a mere 50 percent of the crop's "street" price.

In a scheme of this size, water deliveries are difficult to monitor because of the large distances involved and the complex network of major, minor and tertiary canals. In addition, many of the methods and much of the equipment used are antiquated, dating back to colonial times. Irrigation operations are frequently carried out unofficially or at least unsupervised, especially at lower levels of the system.

The study of agency management used various indicators of performance to assess the adequacy, reliability and equity of water supplies. Three major canals were chosen—Zananda, Gamusia and Kab El Gidad—representing the head, middle and tail areas of the Gezira main canal.

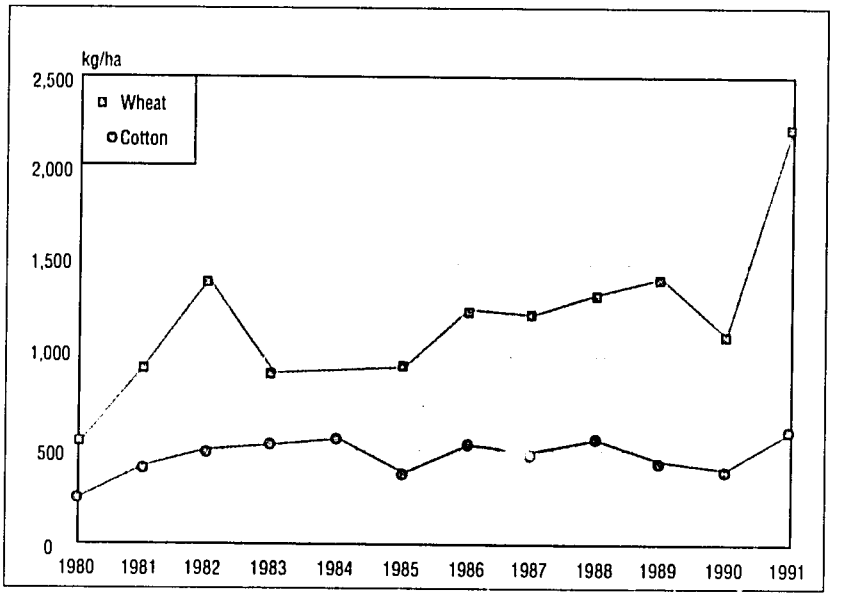
For major canals, the results showed that, while the amounts of water supplied in total were adequate, they fluctuated a great deal within individual reaches. This became apparent only when the

*Figure 2. Trends in areas devoted to wheat and cotton in the Gezira Scheme.*




In 1985 no wheat was planted due to shortage of water.

*Figure 3. Trends in yields of wheat and cotton in the Gezira Scheme.*




analysis was conducted at the level of reaches, not when whole sections or control points only were investigated, since at these levels the averaging effect masked the variations. This masking effect was also apparent for the equity results, which were much less impressive when measured for individual reaches than they appeared to be when measured along sections or at control points (see Figure 4 on page 9).

In the case of minor canals, performance was even less satisfactory, probably due to poor supervision and the poor condition of control structures along these canals.

Another important finding was that surface drainage, officially denied by officials, is in fact widespread in the scheme. This is a major indicator of inefficient water use. The Gezira Scheme was originally designed to allow the disposal of rain-water only. Under a 1959 agreement between Egypt and Sudan, the latter country is supposed to prevent over irrigation and the drainage of excess irrigation water.

The Gezira Scheme is managed partly by the Ministry of Irrigation and partly by the Sudan Gezira Board. Minor canals at present fall into a kind of no man's land between the two agencies, with maintenance being officially the responsibility of the Ministry and operation that of the Board. There is an urgent need to improve management at this level of the system.

Much of the information collected in the scheme at present is unreliable. This is because field workers know that the data they pass to their superiors are seldom, if ever, used by them to manage the system. Under these circumstances, why should they bother to ensure accuracy? Until information is seen to have a direct influence on system operation, its collection will remain a meaningless ritual.

The study on farmers' irrigation practices revealed that water use efficiency (WUE) on the scheme remains very low. This was true even in a year when cropping conditions were ideal and yields rose substantially. Soil moisture content was high throughout the growing season, indicating substantial over-irrigation. The total depth of water applied was significantly higher than the values recommended by the FAO, usually by around 200 to 300 mm.

Chiefly to blame is the rigidity of the socalled indent system—the system by which water is allocated. Despite the predominance of wheat and cotton on the scheme, water indents appear to have been set on the basis of the peak water requirement of the scheme's thirstiest crop, groundnut, which is less commonly grown. This high level is used in order to play safe. Estimates of the monthly water requirements for different crops grown on the scheme are available. They should be used to introduce a crop-based water allocation system.

Up to 10 million tonnes of silt are deposited in the Gezira Scheme each year. Nearly 60 percent of this arrives during the first 3 months of the growing season, when the demand for water is relatively low. Better matching of supply with demand would prevent the diversion of unnecessarily large amounts

of water, thereby reducing the silting problem considerably.

Researchers commonly correlate crop yields with the number of irrigations used. IIMI's results show that this approach often leads to false conclusions. While the number of irrigations may be identical, there may be considerable differences between fields in the amount of water applied. The number of irrigations can be correlated with yields only if the flow rate and irrigation time per unit area are kept constant—conditions that are certainly not met at present.

The current interval between irrigations is 14 days. Field measurements showed that soil moisture fell by an average of only 10 to 15 percent during this period, indicating that the interval could be increased substantially without endangering yields.

Parts of the scheme are now extremely run down. In these areas, siltation, weeds and the malfunctioning of hydraulic structures have led to severe disruptions in the flow of water. Annual losses caused by dead storage and canal overflow are estimated at 210 million cubic meters of water, which is the equivalent of 40 percent of supply during the month of January, when demand peaks and shortages are widespread. As a result of these problems, serious inequity exists in the scheme, with tail ends being almost universally deprived of their fair share of water.

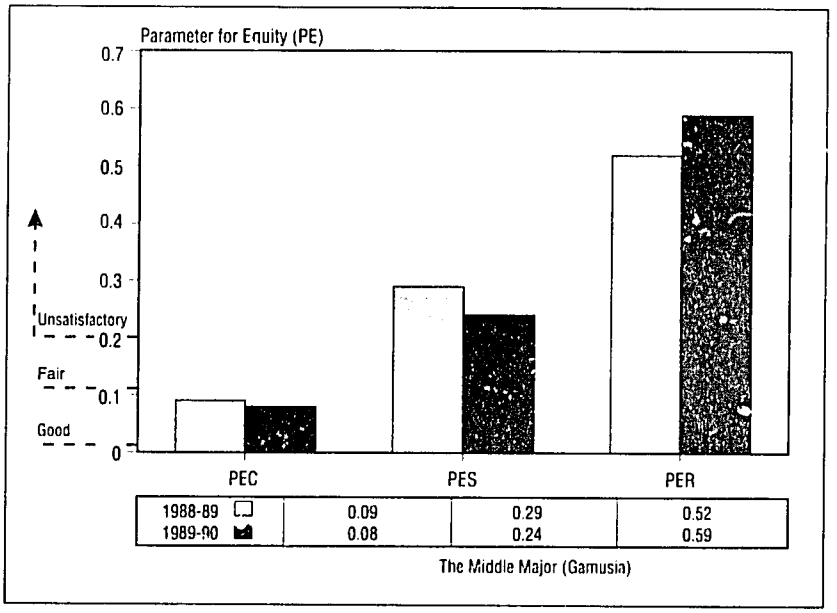
No matter how much water is available, farmers frequently resort to water piracy at present. To discourage this, supervision at lower levels of the system should be improved, preferably with farmer participation. Flow should be regulated according to actual conditions rather than design specifications. Farmers should be made aware that over-irrigation is just as harmful as under-irrigation.

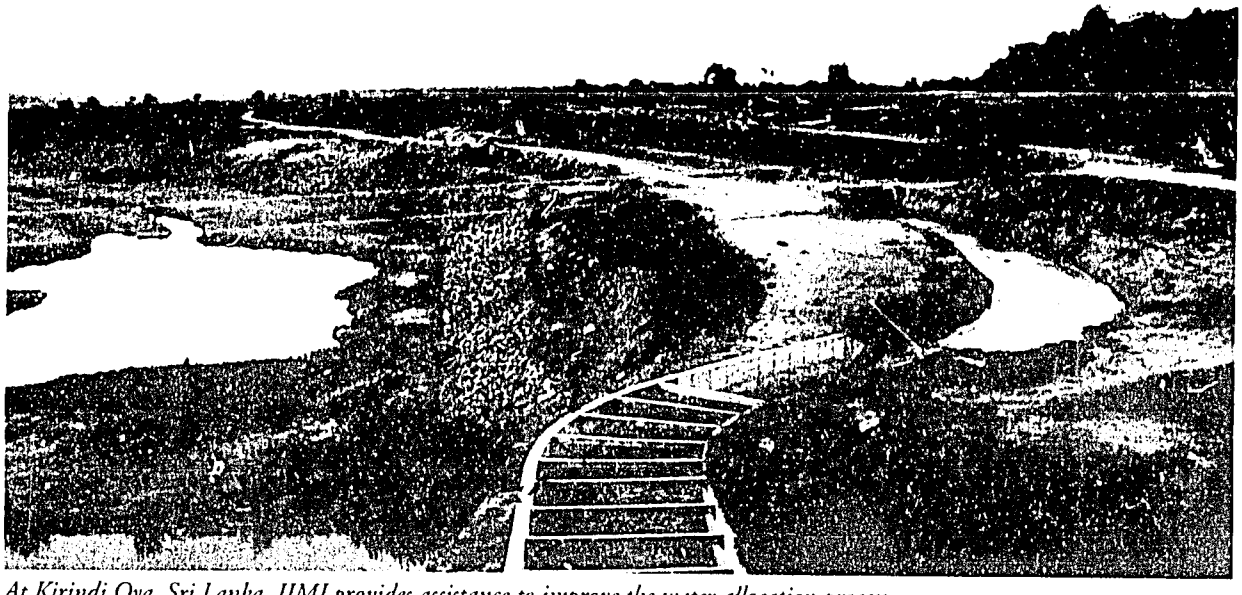
Among the main problems on farmers' fields are that higher-lying areas, estimated at 5 percent of total plot area, are subject to water shortages, while furrows and low-lying areas suffer from prolonged waterlogging.

The current method of irrigating higher-lying areas is to construct dams on the *abu ashreens* (watercourses). This practice lessens the gradient between the minor canal and the *abu ashreen*, reducing flows so that farmers lose some of their share of the water. Instead, higher lands should be irrigated using water in dead storage, which is otherwise wasted. This water could be used if hand pumps were installed. However, high labor costs may make this option impractical.

Up to 30 percent of water can be saved by irrigating two rows with each furrow. An experiment on moisture distribution in uncropped plots showed that water infiltrates uniformly up to about 1.5 meters on both sides of the furrow within 24 hours of irrigation. This suggests it may even be possible to irrigate three rows per furrow. This practice would reduce water consumption markedly.

***Figure 4. Differences in the equity index when measured over sections and reaches and at control points.***





*At Kirindi Oya, Sri Lanka, IIMI provides assistance to improve the water allocation process.*

*Abu sittas* (field channels) currently take too long to convey water along their entire length. This problem could be overcome by relocating *abu ashreens* so that they run through the middle of their command areas instead of along one side of them, as at present. This would reduce the length of the *abu sittas* by 50 percent. No new construction would be needed to implement this. Instead, half the command area of each *abu ashreen* would simply be transferred to its neighbor . This move would also discourage the construction of unauthorized field channels by farmers—a widespread practice at present.

As a result of its studies, IIMI made detailed recommendations covering immediate action to be taken by management, new equipment and facilities, training requirements, and research needs (see Box ).

## RECOMMENDATIONS TO THE AGENCIES

### Action

- At present, water levels and gate openings are routinely recorded only along main canals and at the heads of major canals. This practice should be extended to lower levels in the system, including all control points along major canals. To improve the credibility of the data reported by gate operators, tighter supervision of operations should be introduced.

- Actual deliveries should be routinely compared with targets. Where there is a mismatch, this information should be more rapidly conveyed to the relevant person, using the scheme's telephone system.

- Water distribution should be evaluated on the basis of individual reaches rather than larger sections or control points. This will help identify pockets in the scheme where allocations are inequitable or unreliable.

- Immediate steps should be taken to improve distribution at the tertiary level, which is frequently unsupervised at present.

- To detect problems of siltation and infestation by weeds, managers should incorporate maintenance indicators into their data collection and analysis procedures.

- The desilting of minor canals, currently the responsibility of the Ministry of Irrigation, should be handed over to farmers.

### Equipment and facilities

- To monitor flows efficiently, gauges should be installed at the sluice gates on the main and major canals. Where possible, they should record the flow directly in volume terms—thousand cubic meters per day—instead of in terms of water levels, centimeters or meters. This will make it easier to tell whether or not targets are being met.

- For remote locations where the telephone link is not yet available, walkie-talkie equipment should be provided to key staff.

- To speed up data processing and analysis, computers should be provided to the scheme's senior managers.

### Training

- Field staff should be trained to monitor and evaluate water deliveries and to take corrective action where necessary. This training should be provided by the Water Management Advisory Unit of the Sudan Gezira Bkard.

- The Ministry of Irrigation should also organize local training programs for its staff. This training should provide staff with the necessary skills to evaluate hydraulic performance of main and major canals, using relevant indicators.

### Research

- Since the use of flow measuring devices is problematic under the extremely flat conditions of the Gezira Scheme, flows should be determined by calibrating existing irrigation control structures at regular intervals.

- Losses due to evaporation, seepage and human interference need to be quantified.

- The extent of surface drainage should be measured, so as to determine the net amount of water supplied to crops and fields.

- The development of maintenance needs over time should be monitored, together with changes in efficiency resulting from maintenance work.

- Simple tools and methods are needed to improve the management information available at the level of minor canals. This should stimulate improved flow of information between staff of the Sudan Gezira Board and the Ministry of Irrigation.

- Water deliveries at the lower levels of the system should be studied in further detail, to identify the causes of unsatisfactory performance.

### Pakistan: Is Salinity Here to Stay?

The origins of soil salinity in the Indus Basin are the subject of controversy. In the belief that salinity is primarily associated with waterlogging, past attempts to cure the problem have focused mainly on lowering water tables through the pumping of groundwater—a practice that farmers were keen to adopt anyway because it increased the reliability of their water supplies. The sinking of public and private tubewells gathered pace in the 1950s and 60s, and the conjunctive management of groundwater and surface water is now common throughout the state.

But during the 1980s, the use of groundwater came under growing suspicion. Low quality groundwater with a high salt content might be making matters worse, not better. Research by IIMI, reported in the Institute's 1992 Annual Report, suggested that tail-end farmers experienced greater salinity problems than those in the head and middle sections, the reason being their greater dependence

on poor quality groundwater. Meanwhile, Pakistan's Directorate of Land Reclamation (DLR) indicated that the steady decline in the saline area of the Punjab recorded since the 1950s had come to a halt during the mid-1980s, and had even gone into reverse in some areas.

Soil sodicity is a less well known but perhaps equally serious threat to agricultural production in the Punjab. A high sodium content in relation to other elements such as calcium and magnesium causes clay to swell and clay particles to disperse, leading to a loss of soil structure and reduced permeability. The adverse effects of sodium on soil properties depend strongly on total salt content, as measured by the electrical conductivity of soil solutions.

In 1989, IIMI's Pakistan program began a 3-year project on waterlogging and soil salinity. The objective was to identify management improvements that would mitigate these problems. It was decided that IIMI would confine its research to areas where levels of salinity were still fairly low. The assumption was that areas with high levels would require drainage facilities to lower groundwater tables, or in other words that management interventions alone would not suffice.

Data on soil salinity and sodicity were collected in farmers' fields for 18 sample watercourses at three sites, Farooqabad, Pir Mahal and Hasilpur. For 12 of these watercourses, farmers' irrigation practices were also monitored. The data were collected during three consecutive irrigation seasons, summer 1991, winter 1991/92 and summer 1992.

To assess the buildup of salinity, the electrical conductivity (EC) of both soils and irrigation water was measured. The possible detrimental effect of sodium was assessed by measuring the sodium adsorption ratio (SAR) of saturated soil samples.

At the same time as field data were collected, a soil water flow model, known as SOWATSAL, was used to simulate the processes of salinization in the upper 2 meters of the soil. An attempt was made to validate the model in different irrigation environments, so as to be able to predict future trends in soil salinity.

***Table 2. EC and SAR levels of soil samples from fields in the command area of selected watercourses.***

| Watercourse | EC (dS/m) | | | | | SAR | | | | n |
|---|---|---|---|---|---|---|---|---|---|---|
| | Dec 89 | June 91 | Nov 91 | June 92 | Nov 92 | June 91 | Nov 91 | June 92 | Nov 92 | |
| Ghourdour 1L | | 0.9 | | 0.9 | 1.6 | 4.4 | | 4.6 | 5.9 | 24 |
| Mananwala 24R | | 0.7 | | 0.7 | 1.4 | 2.6 | | 3.3 | 5.2 | 48 |
| Mananwala 71R | 2.6* | | | 1.6 | 1.6 | | | 9.9 | 9.0 | 84 |
| Mananwala 141 | | 3.3* | | 3.1† | | | | 18.0† | | 45 |
| Mananwala 143 | 5.4* | 1.9* | | 2.3 | | | | 17.0 | | 48 |
| Junejwala 8L | | 2.0* | 2.8* | 1.6 | 1.9 | | | 8.3 | 9.0 | 48 |
| Junejwala 29R | | 2.7* | 3.4* | 2.8 | 2.0 | | | 17.5 | 11.1 | 48 |
| Junejwala 46L | | 2.2* | 3.6* | 1.8 | 2.5 | | | 10.1 | 11.4 | 44 |
| Pir Mahal 133 | 6.8* | | 4.5* | 2.9 | | | | 14.1 | | 184 |
| Azim 20L | | | | 1.1 | 1.6 | | | 3.7 | 6.0 | 120 |
| Azim 43L | | | | 1.3 | 3.4 | | | 3.1 | 9.9 | 120 |
| Azim 63L | | 1.7 | 2.2 | 1.3 | 1.5 | | 8.9 | 4.7 | 6.5 | 72 |
| Azim 111L | | 4.8 | 2.1 | 2.3 | 1.8 | | 6.2 | 11.1 | 13.0 | 56 |
| Fordwah 14R | | | | 2.3 | 2.2 | | | 6.1 | 5.7 | 120 |
| Fordwah 46R | | | | 1.0 | 1.0 | | | 3.8 | 5.9 | 120 |
| Fordwah 62R | | 1.1 | 2.4 | 1.5 | 1.4 | | 10.4 | 6.7 | 6.7 | 60 |
| Fordwah 130R | | 1.1 | 1.4 | 1.4 | 1.2 | | 9.2 | 6.8 | 5.6 | 52 |
| Fateh 184R | | 2.4 | 1.5 | 2.2 | 1.6 | | 5.1 | 9.1 | 8.0 | 48 |

*Notes:*
* Measurements taken by the four-electrode probe.
† Slightly lower values were found for three other fields in Mananwala 141R.

Table 2 shows trends in soil EC and SAR over the period of the survey. The figures for EC suggest that farmers managed to keep salinity in check. Only in a few watercourses were many fields found in which salinity had increased by the end of 1992, which was an exceptionally wet year. Indeed, the study identified farmers' fields where salinity levels fell from 8 dS/m, a level damaging to crops, to lower than 3 dS/m within two to three seasons.

On average, SAR levels did not change significantly over the survey period,

suggesting that sodicity may be a greater problem than was previously thought. In some locations, SAR levels improved over one or two seasons. Desilting operations may have played a part here, making more water available for leaching.

*Soil salinity is exacerbated by the excessive use of poor quality groundwater.*

The data show that, contrary to findings reported earlier, there is no clear overall trend of increasing EC and SAR levels with increased distance from the head of distributaries or watercourses. There are cases in which this is true, but plenty of others in which it is not. In the watercourses of the Junejwala minor canal, for instance, EC and SAR levels are significantly *lower* at the tail end than at the head end.

The hypothetical correlation between tail-end locations and the buildup of soil salinity was based on two assumptions: first, that tail-end farmers invariably use a higher proportion of groundwater, and second, that the quality of this groundwater must be inferior to that found near head ends. Neither assumption can be sustained as generally true on the basis of the current data set.

For example, during winter 1991/92, the tail watercourse Fordwah 130R had more water than did Fordwah 62R. Again, measurements of the quality of pumped groundwater in the sample watercourses of the Fordwah command area showed no declining trend from head to tail, either at distributary or at watercourse level.

The decreasing trend in salinity obtained by analyzing soil samples was confirmed by farmers at Hasilpur, where a rapid survey of 200 farmers using 40 watercourses in the Fordwah and Azim distributaries revealed that a majority had observed declining salinity levels over the past 6–7 years.

The fact that farmers have managed to keep salinity at bay is highly encouraging. They have, of course, been helped by low and falling groundwater tables. In all but a few fields the water table was sufficiently low to allow leaching and not cause any upward movement of salt through capillary rise.

By installing tubewells and participating in the water market, farmers have gained increased flexibility in supplies. They can now vary the interval and depth of water applications more accurately according to need. This is particularly important for soils affected by salinity, the chief effect of which on crops is to deprive them of water. This effect can be mitigated by supplying irrigation water more frequently preventing soils from drying out. A survey in the Hasilpur area showed that farmers using tubewell water applied water on average 1.5 times more frequently than those who used none. The average annual depth of applications among tubewell users was 115 mm (20 percent) greater than among non-users.

There is evidence that farmers using tubewell water obtain better yields than those who do not. Besides being able to manage salinity better, these farmers also invest in more inputs such as fertilizers, improved seeds and land leveling. Their guaranteed water supply makes such investments less risky.

The EC levels in irrigation water were also generally low. Only where canal water is scarce and groundwater is of relatively low quality did they exceed the safe limit. An interesting example was provided by Fateh 184, where farmers succeeded in reducing the level substantially between the summer of 1991 and that of 1992. To offset saline groundwater, they drew more good quality canal water.

In contrast, nearly 40 percent of the irrigation water used in the sample areas was found to pose a sodicity risk. Water deemed unfit by this standard was found almost equally present in all sample watercourses.

The data showed no significant correlation between the quality of irrigation water and cropping intensities. Nor did salinity appear to have a marked effect on crop yields at any location. Other management factors are at work, including the number of ploughings and the quantity of seed used. In the case of cotton, farmers were observed using more seed when EC levels in irrigation water were high, thereby anticipating losses after germination.

The validation exercise conducted on the model brought less interesting results. The model cannot account for variations in the efficiency of leaching, caused by such factors as the preferential flow-paths of water through soil, uneven water applications on poorly leveled fields, and changes in the frequency of irrigation. Reasonably good correlations were obtained for cotton and sugar cane, but those for wheat were poor.

The main conclusions of this study are shown in Box . The study has opened up a new possibility—that of building on farmers' own efforts to manage the salt content of their soils. Participatory on-farm work, assisting farmers' own experiments, will be the appropriate way forward for this new line of research.

## SOIL SALINITY: SOME NEW INSIGHTS

The study reached the following conclusions:

- Farmers can successfully manage salinity, provided they have access to irrigation water of reasonable quality and water tables are not too high. Salinity levels in some sample areas have declined over the past 3 years and do not appear to be affecting crop yields.

- The development of tubewells has provided farmers with a tool for improving their irrigation and salt management. Farmers are now more able to vary the depth, frequency and type of irrigation according to need.

- The hypothesis that irrigation management can tackle salinity only in areas where the problem is incipient is a myth. Even where salinity levels were high (EC of 8 dS/m), farmers were able to reduce them in one or two cropping seasons.

- The factors affecting the spatial distribution of saline groundwater are complex. Such water is not invariably associated with tail-end locations. Proximity to groundwater recharge areas (large main canals or link canals) appears to be an important determinant. Field conditions, crop choice, rainfall and the management practices of farmers also play a part. The many variables involved make predicting salinity very difficult.

- There is an urgent need for further research to capture the development of salinity over time. One hypothesis that needs to be tested is that salinity is related to the age of the tubewell. There are some indications that installing a tubewell leads to a short-term decrease in salinity levels as the water table falls, a trend that is later reversed as groundwater is repeatedly recycled. Other variables needing investigation are the depth of the water table and whether it is rising or falling.

- Sodium levels may pose as serious a threat to crop yields as salinity. More needs to be known about the effects of high SAR values on soil texture and their interaction with salinity levels. Further research is also needed on the definition of critical thresholds, which may well be lower than was previously thought. National efforts

should go into the development of gypsum, the conventional remedy widely used elsewhere but accessible to few Pakistani farmers at present. Other possible solutions should also be explored.

- Simple links between different phenomena (e.g., waterlogging and salinity, poor quality groundwater and salinity, tail-end locations and salinity) can be misleading.

## COMPUTER APPLICATIONS

### Improving the Adoption Rate

The number of decision support tools developed by irrigation researchers has proliferated in recent years. Yet despite the widely acknowledged need for such tools, IIMI has had only moderate success in persuading managers to adopt them. In 1993, the Institute analyzed the reasons for failure and proposed a new approach designed to increase adoption rates in the future.

Since the late 1980s, IIMI has studied the use of some 20 decision support packages at various locations in six countries (see Table 3 on page 16). The tools range from relatively simple databases, such as the Irrigation Management Information System (IMIS), to sophisticated scheduling models such as INCA, for matching water supplies to demand. IIMI has developed its own software in-house and has also used packages developed by other agencies.

The reasons for success or failure revolve primarily around:

- The nature of the package itself.
- The nature of the intervention.
- The tool development process.
- The role of IIMI.

*Tubewell development has enabled Pakistani farmers obtain better yields and exercise greater control over soil salinity levels.*

#### *Nature of the package*

Typical failures here include tools that are unfriendly, inflexible or apparently irrelevant.

Many tools are unfriendly to those at the early stages of computer literacy. Some are unfriendly even to more advanced users. A hastily developed or inadequately tested tool may still contain bugs, or the tool may require large amounts of data that have not been (and cannot be) collected. Alternatively, users may have difficulty in interpreting or trusting the output of the tool.

Geographical information systems are the worst offenders here. They are complex, requiring a great deal of patience and training if users are to become confident. The process of digitalizing maps is frustratingly slow. Similarly, the Anderson-Maas model, used to assess crop water requirements in Indonesia, presented special difficulties, requiring highly tedious data input formatting in which a single error could lead to the failure of the program to run.

*Table 3. Decision support packages tested by IIMI.*

| Type of tool (and software) used | Location (and date) of intervention | Tool developer |
|---|---|---|
| Water balance model (spreadsheet "TARC") | Sri Lanka (1991) | IIMI (HQ) |
| Probability inflow model (Spreadsheet "PRO") | Sri Lanka (1992) | IIMI (SLFO) |
| Management simulation model (COMA) | HQ (1990) | IIMI (HQ) |
| Management information system (IMIS) | Sri Lanka (1991) | IIMI (HQ) |
| Management information system (IMIS) | Sri Lanka (1991) | IIMI (HQ) |
| Management information system (IMIS) | Pakistan (1991) | IIMI (HQ) |
| Open channel hydraulic simulation model (RBMC, SIC) | Sri Lanka (1990) | CEMAGREF/ IIMI (HQ) |
| Open channel hydraulic simulation model (RBMC, SIC) | Pakistan (1992) | CEMAGREF/ IIMI (HQ) |
| Open channel hydraulic simulation model (SIC) | Pakistan (1992) | CEMAGREF/ IIMI (HQ) |
| Open channel hydraulic simulation model (SIC) | Burkina Faso (1992) | CEMAGREF/ IIMI (HQ) |
| Open channel hydraulic simulation model (MISTRAL/RAJBAH) | Pakistan (1990) | SOGREAH/ IIMI (PAK) |
| Water balance model (ROSES) | Sri Lanka (1993) | CONSULTANT/ IIMI (SLFO) |
| Expert system (NEXPERT) | India (1989) | COMMERCIAL/ IIMI |
| Linear programming package (Lindo) | Sri Lanka (1991) | COMMERCIAL/ IIMI |
| Open channel hydraulic simulation model | Pakistan (1992) | DELFT HYDRAULICS |
| Crop water requirement and scheduling model | Pakistan (Sri Lanka, Sudan) (1987) | FAO |
| Scheduling model | Indonesia (1988) | HARVARD |
| Planning and scheduling model | Sri Lanka (1992) | HR WALLINGFORD |
| Salinity model — (SOWATSAL) | Pakistan (1990) | USU |
| GIS Package | Pakistan (1992) | ITC HOLLAND |

An inflexible tool is one that cannot be adapted to the environment in which it is used. For example, early versions of the Simulation of Irrigation Canals (SIC) program were unable to cope with the type of outlet structure found in Pakistan, having been designed for systems in Sri Lanka, where a different design is used.

Even if a tool is user-friendly and flexible, it will still fail if it does not do something that the user can identify with. Generating the same outputs as those traditionally obtained manually should be the first area of application when introducing a new tool. This builds trust and stimulates interest in trying more innovative applications later.

### Nature of the intervention

Decision support tools should not be introduced in isolation but only as part of a comprehensive effort to improve management attitudes and performance. Moreover, they have to be introduced at the right level in the management hierarchy. Operational tools introduced at middle management level depend on a strong data collection and transmission system at

junior management and field levels. For example, the introduction of SIC on the Kirindi Oya Right Bank was at first unsuccessful because no database was available, so managers were unable to appreciate its usefulness. Once IMIS had been established, the prospects for using SIC improved.

In the more bureaucratic agencies, decision-making packages are frequently anathema to middle managers, who simply do not like taking decisions, especially if this means departing from established procedures laid down by their seniors. Many agency staff prefer not to risk continuing to use a decision support package once the pilot project is over and the partner institution has withdrawn.

A classic example is the use of the RAJBAH model for assessing the benefits of selective desilting in Pakistan. No one disputes the validity of the model, nor the performance improvements it brings. Yet the package remains completely unused by anyone other than IIMI researchers. This is partly because the tool itself requires large amounts of field data for calibration. However, institutional resistance is also extremely strong, with the agency concerned reluctant to change its current methods of allocating maintenance budgets.

These difficulties highlight the importance of a careful diagnosis of problems before attempting to introduce a decision support package. If tools are developed without this process being followed, the end result is often an intervention looking for a test location—a tell-tale sign of supply-driven research carried out without due regard for users' needs.

### *Tool development process*

Various modes of intervention are possible when developing and introducing decision support packages. These range from a 'turnkey' approach, in which the user receives a ready-made package, to more participatory approaches in which the user selects the tool and adapts it to local circumstances, or even plays a role in tool design and development. The mode of intervention must be chosen carefully, since it affects the timespan and costs involved, as well as the chances of success. IIMI's experiences show that participatory approaches tend to be more successful, especially if the tool is to be institutionalized rather than used to solve a one-off problem.

Tool development and adaptation take time, requiring continuity of funding and stable institutional conditions. The short timespan of many donor-funded projects, including those of IIMI, makes them unsuitable testing grounds. The field of tool development is an obvious example of the way in which the trend away from core funding prejudices long-term, strategic research.

### *Role of IIMI*

When IIMI first began developing decision support tools there was some resistance from staff and stakeholders, who felt that such an activity did not fall within the Institute's comparative advantage. They argued that other institutions were better placed to develop tools, and that IIMI's role was to test and adapt them.

Analysis showed that this adaptive research role has not been very successful. Tools developed without IIMI's involvement have met with low levels of acceptance by agency staff. Success has occurred either when IIMI has developed tools itself or, more often, when it has worked closely with tool developers in identifying and articulating the real needs of users. In recent years there has been an increased tendency to work in this way.

### Action Package

IIMI has developed an action package to increase the success rate of adoption. The package is currently being tested in two irrigation systems, the Kirindi Oya Right Bank Main Canal System in Sri Lanka and the Fordwah branch canal system in Pakistan.

Having identified the different modes of intervention, the package describes three stages in

the intervention process. The first is the diagnostic phase, in which the key constraints to improved performance are identified and an appropriate decision support package is selected. Next comes the action phase, consisting of the installation of the package, training in its use, and the setting up of any additional data collection required (see Box ). Last is institutionalization—the process by which the intervention is integrated within the adopting institution, which becomes its 'owner.'

## THE ACTION PHASE

The action phase has nine steps:

1. Define the prototype tool with the canal manager. Using the results of the diagnostic phase, the researcher and the system manager agree on a provisional configuration of the tool and its expected role and impact.

2. Survey the physical system. The permanent data required by the tool must be collected. In the case of flow simulation, these cover such areas as control structures and canal topography.

3. Build staff awareness. Staff involved in, or affected by, the installation of the tool are brought into the process, usually through a meeting convened by the manager to explain the tool and its uses.

4. Set up a data collection and transmission system. The availability of dynamic data (e.g., on discharges) is reviewed. Where new data are needed, data collection formats are designed, and staff are trained to record, transmit and enter data.

5. Introduce data analysis. This enables managers to build a picture of how the system under their control performs over time. Together with their staff, they can now identify operational problems and discuss possible solutions.

6. Examine the validity of current targets. Real performance can be compared with targets and discrepancies identified. Steps can then be taken to improve or revise the rules and procedures underlying the setting of targets.

7. Initiate control activities. Where gaps between measured and targeted performance are detected, control operations can be introduced.

8. Tackle special difficulties. For the most complicated decisions optimization tools can be used and, if necessary, the proposed decisions tested using simulation models before they are introduced.

9. Evaluate impact. The effects of the package on system performance should be assessed at the end of each season. This enables improvements to be proposed.

The diagnostic phase at Kirindi Oya revealed the importance of improving distribution operations so as to make the most of the system's scarce water supplies. It also highlighted the critical role of seasonal planning for deciding on rational allocations.

At Fordwah, inequitable deliveries resulted from deficiencies in the operations of the main distribution network. The equity objectives espoused by system managers were being subverted by operating staff under pressure from specific groups of farmers. In parts of the command area, the buildup of soil salinity posed a serious threat. Scheduling, distribution, on-farm practices and drainage were all critical areas.

The action phase at both locations confirmed the validity of the nine-step approach depicted in the

Box. Staff involvement proved a prerequisite to success, with the joint survey (step 2) creating the basis for more intensive collaboration in the development of an improved data collection and transmission system (step 4). Staff at Fordwah took the initiative during the latter step, frequently requesting the joint calibration of structures. The introduction of data analysis (step 5) was pivotal in securing the commitment of staff. At Kirindi Oya, how to set and achieve targets became a major subject for discussion between the manager and his staff. The fact that the impact of interventions could be seen brought home the value of the intervention. In both schemes, the analysis of data is now fully operational.

In Kirindi Oya, the database proved especially useful when the manager faced an inquiry by an independent committee over alleged unfair allocations. The transparency of past distribution helped him defend his decisions.

At both schemes, introducing public display boards in and outside the manager's office brought immediate benefits. Providing a handy overview of the system for the first time to managers and staff together, the boards constituted a focal point for discussing and clarifying the problems of water distribution.

Farmers and field staff said that greater awareness of water distribution on the part of the manager had led to increased accountability at lower levels of the system. The number of gate manipulations decreased in both systems, reducing the fluctuation of water levels in the main canals.

It is too early yet to tell what the outcome of the institutionalization phase will be, but the signs so far are encouraging. The manager at Kirindi Oya has appropriated the intervention and performed training in other schemes. On a visit to Pakistan in 1993, he stressed the effectiveness of the tools he is using in providing a good information system. The progress of institutionalization in Sri Lanka is summarized in Box .

**INSTITUTIONALIZATION OF WORK ON DECISION SUPPORT PACKAGES IN SRI LANKA'S IRRIGATION DEPARTMENT**

**Mid-1980s:**

Isolated initiatives by enthusiasts; no institutional support.

**Late 1980s, early 1990s:**

A few pilot interventions by foreign consultants or organizations, importing software, skills and computers; no widespread impact, but some useful site-specific results and increased general awareness.

**1992:**

Establishment of the Irrigation Research Management Unit (IRMU) as the research arm of the Irrigation Department.

**1993:**

IRMU organizes a national workshop analyzing past experiences in the use of decision support packages as a basis for planning future efforts leading to the formation of a working group on decision support packages within the Irrigation Department.

**1994 onwards:**

Work will continue at a broadening range of locations, with IRMU playing a coordinating role.

The establishment of the IRMU within the Irrigation Department as an institutional 'home' for evaluating and promoting innovations was a big step forward, serving as a catalyst in the formation of a dedicated working group on decision support packages. Thus a long process of awareness building has crystallized in a new national initiative that operates relatively independently of IIMI.

# THEME 2: PERFORMANCE ASSESSMENT AND IMPROVEMENT

Improving the performance of irrigated agriculture is the objective of all IIMI's work. But, in complex systems such as those of irrigation, what exactly constitutes good performance? High yields of irrigated crops are obviously an important indicator, but they do not tell the full story, since water and/or other inputs may have been used profligately and unsustainably to obtain those yields. In addition, yields may be high in one part of the system—near the head end—but low for farmers at the tail end, who are often deprived of their fair share of the critical resource. Clearly, in assessing performance, efficiency criteria will be just as important as those of effectiveness. And criteria for sustainability and equity will be needed alongside those indicating productivity.

The primary aim of IIMI's research under this theme is therefore to develop methods for use by policymakers and planners in assessing performance. In addition, IIMI conducts various studies with the aim of directly improving performance in individual systems.

In 1993, IIMI and its partners conducted important strategic research on the development of a framework for assessing performance, accompanied by a comprehensive set of indicators (see Box ). The concepts and methods developed as part of this research have been, and will continue to be, tested and applied in studies on various irrigation systems in the developing world. This year we report on three such applied studies. The first presents a capacity audit approach designed to make the assessment process more objective. It examines the validity of this approach by applying it to irrigation systems in Sri Lanka, India and Pakistan. The second investigates the performance assessment practices currently used by managers in Nepal, Sri Lanka and the Philippines, with a view to finding out whether these actually helped them to improve performance. The third study analyzes main system management on large-scale schemes in India and Sri Lanka.

Several studies related to performance improvement were completed during the year. We have chosen to highlight diagnostic research conducted in Burkina Faso, which yielded important data on the performance of reservoir-based systems under farmer management. Two major studies to improve the management of Sudan's Gezira Scheme were also completed, but because of their major emphasis on water delivery and disposal these are reported under Theme 1 (see page 7).

## DEVELOPING A FRAMEWORK: SOME NEW CONCEPTS

If they are to improve irrigation performance, managers need a conceptual framework that helps them understand the context of their efforts and make the best possible use of the data they are collecting. The complexity of irrigation systems—their multiple managers, clients and stakeholders and the different objectives they must meet—has hindered the development of such a framework in the past.

IIMI's research, conducted in collaboration with the International Food Policy Research Institute (IFPRI), the International Institute for Land Reclamation and Improvement (ILRI) and the international Institute for Hydraulic Engineering (IHE), has led to the development of several important new concepts that help to clarify thinking on the subject. These concepts fall under two major approaches.

The first approach is that of nested systems, reported in detail in IIMI's 1992 Annual Report.

Here the irrigation system is thought of as the lowest level in a hierarchy, in which the outputs of one level become inputs into the next. The five systems in the hierarchy are the *irrigation system,* the *irrigated agriculture system, the agricultural economic system, the rural economic system,* and the *politico-economic system.* Another important concept in this approach is that of the three different kinds of performance measure. These are *process measures,* which are internal to a system and assess that system's efficiency in delivering outputs, *output measures,* which describe the quantity and quality of outputs at the point where they become inputs into the next higher system; and *impact measures,* which gauge the impact of these outputs in a broader context.

The second approach is directly related to the task of diagnosing and improving organizational performance. In this approach, performance has a twofold definition, consisting of the degree to which an organization's products and services meet the needs of its clients, and the efficiency with which the organization uses its resources. The major concepts here are that of the *management process* (see Box on page 24), and the *performance assessment system* (see Box on page 24).

For diagnostic purposes, three different categories of performance may be identified: water supply performance, which deals with the primary responsibility of irrigation managers; *agricultural performance,* which covers such direct effects of irrigation as area cropped, cropping intensity and yields; and *economic, social and environmental performance,* which assesses the indirect broader impact of irrigation. For each category, IIMI and its partners have developed a set of relevant indicators.

This research is reported in detail in a prize-winning synthesis paper shortly to be published in *Irrigation and Drainage Systems.*

## PERFORMANCE ASSESSMENT

### Auditing the Capacity to Improve Performance

Evaluating the performance of an irrigation system is often a highly subjective business. On the basis of a brief survey, an observer comes to an opinion as to whether the system is performing well or badly. Often these initial impressions prompt him or her to make recommendations that serve as the basis for a subsequent project.

This approach is fraught with danger. The assessment is greatly influenced by the experience and skills of the observer, who brings personal biases and interests into the process. It is likely to be based mainly on physical evidence—the condition of canals, the growth of crops, variations in deliveries between head and tail, and so on—since information of this kind can be gathered fairly quickly and is relatively easy to analyze. The less tangible aspects of performance, such as participation by farmers in decision making, or the capacity of the system to respond to changing needs, tend to be ignored.

IIMI has developed an approach that helps to overcome these problems. The aim was to make the evaluation process more objective and systematic, providing observers with a common set of questions that will enable them to predict a system's capacity for change and to compare capacity across systems. A further aim was to help observers identify those areas of a system in which change is most needed, and hence the kinds of intervention required.

The *capacity* to improve performance differs from the *potential* for improvement. A system that performs poorly may have a high potential to improve performance but a low capacity to actually do so. Conversely, a system that is already performing well may have less potential for improvement but a greater capacity for it.

The capacity audit consists of five sets of questions covering:

- Design: Can the system's physical infrastructure be managed so as to meet system objectives?

- Operation and maintenance: Are water deliveries planned and implemented, and is the system maintained in such a way as to enable objectives to be met?

- Data collection: Is sufficient information being collected to determine whether targets and objectives are being met?

- Management framework: Are data used as part of a systematic process of control and evaluation?

- Incentives and willpower: Are the individuals and organizations involved in system management sufficiently motivated?

Using the answers to questions in these five areas, it is possible to score different systems, enabling their capacity for improvement to be assessed and compared.

IIMI tested this approach by applying it retrospectively to five irrigation systems in which it has worked in Sri Lanka, India and Pakistan. Two of the systems had been subject to a long history of interventions to improve their performance. These systems were scored twice, to capture performance before and after the interventions.

Table 4 shows the results. The total score, at the foot of the table, indicates the relative ease with which performance can be improved, with a high score indicating good capacity. A low score does not mean that the system is beyond hope, but it does mean improvements will be harder to achieve.

The individual scores for each set of questions are also important. Scores for specific sets provide guidance for the design of interventions, indicating whether the emphasis needs to be placed on physical, managerial or institutional improvements. This allows the evaluator to select interventions more systematically, choosing only those that best address the identified constraints rather than those that happen to be in vogue. Many institutes, including IIMI, are guilty of promoting an innovation because it is thought to have been successful elsewhere or because it lies within the expertise of a particular staff member.

Conducting the audit before and after an intervention makes it possible to see whether the intervention really worked, or merely brought about a short-term improvement.

The scores allow several hypotheses to be put forward for further testing:

- If the total score is low, then the probability of a single intervention proving successful is also low. Improvement is likely to require a combination of two or more interventions.

***Table 4. An audit of the capacity to improve performance in five irrigation systems.***

| | Gal Oya (1981) | Gal Oya (1993) | Mahi Kadana (1993) | Kirindi Oya (1989) | Kirindi Oya (1993) | Inginimitiya (1993) | Chashma Right Bank (1993) |
|---|---|---|---|---|---|---|---|
| Design | 1 | 2 | 2 | 1 | 1.5 | 1 | 1 |
| Operation and maintenance | 1 | 2 | 1 | 1 | 1.5 | 1 | 0 |
| Data collection | 1 | 2 | 1 | 1 | 2 | 1 | 0 |
| Management framework | 0 | 1 | 1 | 0 | 2 | 0 | 0 |
| Incentives and willpower | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| Total | 3 | 8 | 6 | 4 | 8 | 3 | 1 |

*Notes:* 0 = Low capacity for performance improvement.
1 = Moderate capacity for performance improvement.
2 = High capacity for performance improvement.

At Inginimitiya, a single intervention was chosen—the introduction of a computerized decision support system that would enable managers to better match water deliveries with crop demand. The intervention failed because management showed little interest in using the system and staff were not organized to collect the necessary data.

- A low total score also suggests that the time required to

*Several studies related to performance improvement were completed in 1993.*

improve performance will be significant, making long-term commitment necessary.

An unsatisfactory system in 1980, Gal Oya was working well by 1990. However, it took the entire 10 years, and a substantial investment of US$20 million, to reach this level of performance.

The current low score ap Inginimitiya suggests that short-term inputs will have little or no impact. The conditions here are similar to those at Gal Oya in 1980 and Kirindi Oya in 1986. A long program of phased interventions is likely to be needed.

- A very low total score may require a radical rethink of project objectives.

  At Chashma, where the total score is very low, the mix of interventions required is even more complex than at Gal Oya. A rehabilitation project has been attempting to promote a change from supply- to demand-based water deliveries, but there has been so little progress in realizing this objective over the past 8 years that a different approach may now be needed. In these cases it is probably best to start with the institutional dimension, since this sets the scene for other improvements. Change will be slow and expectations must be modest at each stage, until the entire package is in place.

- A high total score suggests that a single appropriate intervention has a high potential for further improving performance.

  At Mahi-Kadana there are few design constraints and officials express considerable interest in improving performance. The single intervention proposed is the introduction of a better management information system. This will help managers correct weaknesses in system operation and maintenance.

- Attempting to improve a low score in one area of concern while allowing others to remain at zero is unlikely to result in significant performance improvements.

  If the audit indicates a serious constraint in one or more areas and only moderate constraints in others, improvements in performance will be limited if the package does not address the more serious constraints. At Inginimitiya and Chashma, interventions were too limited in scope, whereas at Gal Oya and Kirindi Oya they were more comprehensive. Managing several interventions at once is more difficult than managing only one, but it increases the chances of success in the longer term.

The study concluded that the audit is a useful tool for analyzing the capacity of a system to respond to management interventions, and for identifying the type of intervention that will be appropriate. It also helps to predict whether improvement is going to be comparatively simple, having a relatively short gestation period and relying on a single intervention, or whether a mix of interventions spread over a longer time period is required.

Using the audit in retrospect may provide IIMI and its partners with insights into why some projects have been more successful than others. This learning process should enable them to design better projects in the future.

### Current Practices and their Impact

Understanding current performance assessment practices is a prerequisite to introducing better ones. Yet surprisingly, little information is available on how irrigation managers actually do assess the performance of their systems. And there is still less information on the critical question of whether assessing performance makes a difference. Do systems that assess their own performance tend to perform well?

To answer this question, IIMI compared performance assessment practices and actual performance in three irrigation systems—Pathraiya in Nepal, Inginimitiya in Sri Lanka and Nayom-Bayto in the Philippines. Data were collected through field visits and by analyzing previous research results and agency records.

The study examined three hypotheses. The first was that a complete and effective management process is a necessary condition for achieving good performance (see Box below).

#### THE MANAGEMENT PROCESS

The management of irrigation, like that of other fields, may be thought of as a cycle consisting of the following sets of tasks:

- Planning: The process by which objectives are set, operational targets are identified and implementation is planned.
- Implementation: The agreed plan is put into action, usually by middle management and staff.
- Monitoring: Management information is collected so that implementation can be checked to ensure that operations are carried out efficiently.
- Evaluation: Performance is analyzed to determine whether the objectives were met. The results of evaluation are fed back into the next planning stage.

If one or more of these sets of tasks is absent, the cycle is incomplete and consequently ineffective. The quality of the cycle also affects performance. Even if the cycle is ostensibly complete, weaknesses at any point will lead to lower levels of performance.

The second hypothesis is that the use of a performance assessment system is also a necessary condition for achieving good performance (see Box below).

#### THE PERFORMANCE ASSESSMENT SYSTEM

An effective system for assessing performance has the following characteristics:

- The collection of a minimum set of data that are accurate and made available to managers on time and in a usable format.
- A clearly defined set of targets for the manager to aim for (and standards describing the acceptable range of values around targets).
- A set of performance indicators combining target values with actual values (usually in the form of ratios).
- A capacity to use the performance data to monitor operations and evaluate the results.

If one or more of these characteristics are absent, the performance assessment system is incomplete and therefore ineffective.

In assessing performance, two questions must be answered:

- "Am I doing things right?" This question addresses operational performance. Answering it requires regular measurements of the system's inputs and outputs.
- "Am I doing the right things?" This question addresses strategic performance. That is, whether available financial and human resources are being used effectively and whether achieving operational targets also meets the broader objectives of the system.

The managers of canal irrigation systems are—or should be—concerned with both types of performance. Higher-level managers, as well as policymakers and planners, tend to be more concerned with strategic performance.

An effective management process and a system for assessing performance are necessary but not sufficient conditions for achieving good performance. The creation of institutional conditions that enable or require managers to improve performance is also essential. Public-sector irrigation organizations in developing countries have a bad record in this respect. Few make available the necessary human and financial resources for running irrigation systems efficiently. Even fewer provide incentives for doing so. Accountability to clients is rare and bad performance goes unpunished. New management practices are often introduced into settings lacking the institutional conditions necessary for their success.

IIMI's third hypothesis, therefore, was that institutional conditions which both enable managers to do their jobs well and provide them with the necessary incentives are prerequisites for achieving good performance.

***Table 5. Presence and quality of the management cycle in the three systems.***

| Management cycle | System | | |
|---|---|---|---|
| | Nayom-Bayto | Pathraiya | Inginimitiya |
| *Planning:* | | | |
| Clear objectives | 2 | 1 | 1 |
| Specific targets | 2 | 1 | 1 |
| Consultation with farmers | 2 | 1 | 2 |
| Systematic feedback of previous season's results | 2 | 0 | 0 |
| *Implementation:* | | | |
| Follows plan | 2 | 2 | 1 |
| Flexibility (responsive to rain, etc) | 2 | 2 | 1 |
| Communication of changes to farmers | 2 | 2 | 1 |
| *Monitoring:* | | | |
| Regular data collection | 1 | 0 | 1 |
| Indicators: compare $\frac{\text{actual}}{\text{target}}$ | 2 | 1 | 1 |
| Indicators used to adjust operations ("Doing things right?") | 2 | 0 | 0 |
| *Evaluation:* | | | |
| Data used to analyze results ("Doing right thing?") | 2 | 0 | 0 |
| Total score | 21 | 10 | 9 |
| Percentage of possible score | 95 | 45 | 41 |

*Notes:* 0 = absent.
1 = present but flawed or ineffective.
2 = present, effective.

Table 5 shows the presence and quality of the management cycle for the three systems. The differences between Nayom-Bayto and the other two are striking. Nayom-Bayto possesses a clear, systematic management cycle which is rigorously pursued by management and staff. Both the other systems have serious weaknesses in their cycles. They do not assess performance and a strategic management process is lacking altogether.

The performance indicators actually used in the three systems are shown in Table 6 on page 26, organized according to the categories of performance identified in the Box on page 24. In spite of important gaps, the assessment system at Nayom-Bayto is well developed compared with that of the other two systems, covering a wider span of categories to an acceptable standard. The most important indicator used here is the viability index—the ratio of

income from farmers' dues to expenditure by the agency. This is used both as a measurement of financial performance and as a proxy for farmers' satisfaction with the agency's service.

Nayom-Bayto also stands out by reason of its incentives to both managers and staff. Salary increments are determined through a formal performance rating system in which points are given for the system's water use efficiency, cropping intensity, maintenance record, rate of collection of farmers' fees, and viability (income compared to expenditure). Bonus points are given for exceeding targets. Staff at all levels receive cash incentives when the performance index is better than 1. These positive institutional conditions appear to have had an important impact on staff motivation.

In contrast, officials at both Pathraiya and Inginimitiya seem to lack motivation and display little interest in the performance of their system. Neither agency has a systematic process for evaluating staff performance, and neither offers incentives for good performance. Staff in both systems are more interested in their construction duties (for which there are incentives) than in operating and maintaining the system efficiently.

Table 7 on page 27 summarizes the data on the actual performance of the three systems. Not surprisingly, Nayom-Bayto emerges as the strongest performer.

The indicators on financial viability are what set Nayom-Bayto apart from the other two systems. This is the only system in which farmers pay irrigation service fees. The agency concerned uses financial criteria both as its major indicator of system performance and for evaluating its own staff. These are highly significant factors in its superior performance.

***Table 6. Performance indicators actually used by management agencies in the three systems.***

| System | Performance indicators used | | |
|---|---|---|---|
| | Water delivery | Agricultural | Other |
| Nayom-Bayto | Supply status<br>farmer feedback<br>Maintenance: canals satisfactory / total canals | Area irrigated<br>Paddy yields<br>Cropping intensity | Viability index<br>Collection efficiency<br>Irrigation authority performance:<br>contract performance,<br>fee collection,<br>efficiency,<br>no. of meetings |
| Inginimitiya | Reservoir levels<br>Water duty (total sluice release/area)<br>Actual deliveries/ rotation schedule<br>Farmer feedback<br>Maintenance: Dates farmers clean field channels/date expected | Crop calendar: actual / planned<br>Season start date<br>Last water issue date<br>End of land preparation<br>Intensity, yield informally noted | Farmer satisfaction<br>Farmer incomes |
| Pathraiya | Actual deliveries/ rotation schedule<br>Farmer feedback | None (yield and area data collected but not used) | None |

Aside from having a complete and relatively effective management cycle and making systematic use of performance indicators, Nayom-Bayto has two other features absent from the other systems: a strategic management process, in which farmers and the agency review the results obtained at the end of each season and adjust the targets for the next season accordingly; and an institutional setting that rewards performance in terms directly linked to system management objectives. Through the use of its viability index, this system achieves greater accountability than the other two.

The study concluded that having a performance-oriented institutional setting is a prerequisite to the introduction of an effective management cycle, including both a performance assessment system and a strategic management process. These ingredients are key determinants of irrigation

*Table 7. Actual performance of the three systems.*

| Indicator | System | | |
|---|---|---|---|
| | Pathraiya | Nayom-Bayto | Inginimitiya |
| *Water supply performance* | | | |
| Water delivery | Not measured | Not measured | Reservoir only |
| Efficiency | Not measured | Not measured | Actual 114% / Planned |
| Adequacy | Poor | Acceptable | Poor |
| Predictability | Acceptable | Acceptable | Poor |
| Equity | Poor | Acceptable | Poor |
| Maintenance | Poor | Acceptable | Poor |
| *Agricultural performance* | | | |
| Area: actually irrigable / design (ha) | 1333 / 1840 (72%) | 1500 / 2000 (75%) | 2643 / 2550 (104%) |
| Cropping intensity: actual / design | 140 / 100 (140%) | 164–169 / 179–185 (92%) | 79 / 165 (48%) |
| Yield: actual (t/ha) 1992 / design | 2.43 / ? | 3.85 (85%) / 4.50 | 3.54 (88%) / 4.00 |
| *Economic viability* | | | |
| Total financial viability (%) | Low | 119 | 35 |
| Financial self-sufficiency | Low | o.k. | Low |
| Fee collection (%) | No fee | 99.6 | No fee |
| Profitability | No data | No data | No data |
| *Social viability* | No data | No data | No data |
| *Environmental sustainability* | No data | No data | No data |

performance. Policymakers should focus their efforts on creating these conditions, rather than on attempting to introduce practices for which there is no supporting framework and no incentive structure.

## Scarcity Leads to Efficiency: Main System Management in India and Sri Lanka

In 1993, IIMI completed a comparative study of main system management in five large-scale irrigation systems—Uda Walawe and Kirindi Oya in Sri Lanka, and Eastern Gandak, Mahi-Kadana and Tamiravaruni in India. The aim was to identify relationships between management, system performance, and the physical and institutional features of the systems.

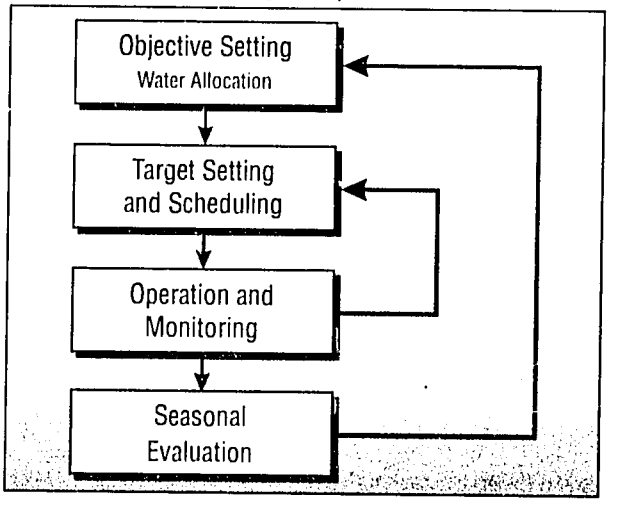
The study investigated the degree to which the four major steps of the management process (see Figure 5) were adequately followed in each system. It also looked at various factors to determine their influence on management performance. These factors included size of system, the ratio of water supply to demand, the physical condition of the system, the management resources, the degree of farmer involvement and the availability of a system database.

The results suggest that water shortages have a beneficial effect on management performance, acting as a 'shock to the system.' Despite its problems, water-scarce Kirindi Oya was the only system in which agency officials made serious attempts to stick to targets and to manage by objectives. This may be contrasted with the much less-impressive performance of management at Gandak, where the demand for irrigation water is relatively low.

Both the Sri Lankan systems differed from the Indian systems in two important respects, the degree of farmer involvement and the development of system databases.

Sri Lanka has adopted a policy of participatory management that calls for farmer involvement not only at tertiary levels of the system but also, jointly with officers, at system level. No such policy has

*Figure 5. Main system management process.*



*Research on main system management in large-scale irrigation schemes in India and Sri Lanka reveal that water scarcity leads to efficiency.*

been implemented in India. Among the Indian systems, farmers' organizations had evolved only at Tamiravaruni, where the gap between water supply and demand was relatively great and pressure tactics were used to influence managers' decisions on allocations. In none of the Indian systems except Mahi-Kadana were farmers consulted at the start of the season on the area to be irrigated and the crops to be grown.

In both the Sri Lankan systems, good data on water deliveries and other features were collected and reported to system managers regularly. This was in large part due to IIMI's interventions. Among the Indian systems, only Mahi-Kadana had a satisfactory management information system, although this is not yet fully used by managers.

These differences may partly reflect size differences. All the Indian systems are significantly larger than the Sri Lankan systems, making consultation and communication more difficult.

Farmers' attempts to impose their wishes on system management were strongest in Kirindi Oya and Tamiravaruni—the two systems in which water was scarcest. In Tamiravaruni, management had failed to take changing cropping patterns into account: a switch to banana in recent years had markedly increased the demand for water and its time of supply.

At Kirindi Oya, IIMI has been working with the agency for 6 years to improve operations. There is a similar, albeit more sporadic, history of outsiders working at Mahi-Kadana, but without similar impact.

The study reached the tentative conclusion that systems must experience both water scarcity and outside pressure before management by objectives is fully adopted and applied. Outside pressure alone is not enough. In addition, system managers badly need methods and tools to support their decision making. Tools must rely on a far more detailed knowledge of systems than most managers currently possess, implying the introduction of improved data collection systems as a condition for success.

## PERFORMANCE IMPROVEMENT

### Performance under Local Management in Burkina Faso

Most of Burkina Faso's larger irrigated schemes are located in the wetter southwest of the country, where rivers can be exploited. The smaller reservoir-based schemes are distributed mainly across the central plateau, and are often clustered round the large urban centers that constitute their markets (see Figure 6). There are about 70 such schemes in the country, totaling an irrigated area of around 3,000 ha. The five schemes studied by IIMI were Mogtédo, Itenga, Gorgo, Dakiri and Savili.

The Gorgo and Itenga schemes suffer from a shortage of water, but at Mogtédo the water resource is more abundant than was originally thought. This has given rise to the spontaneous expansion of the irrigated area, described in IIMI's 1992 Annual Report (see Box ).

### THE PRIVILEGED FARMERS OF MOGTEDO

Most farmers in the Mogtédo Scheme typically possess an irrigated holding of 0.25 ha, all of which is cultivated to rice in the wet season and less than half of which to vegetables in the dry season. However, around 15 percent of farmers have been able to use their social and economic standing in the community to bring under irrigation relatively large areas of land lying outside the system's official command area. On average, a privileged farmer of this kind cultivates 0.65 ha, comprising an official holding of 0.25 ha and an unofficial one of 0.40 ha. The whole of this area is cultivated to rice in the wet season, and about 0.5 ha to other crops in the dry season.

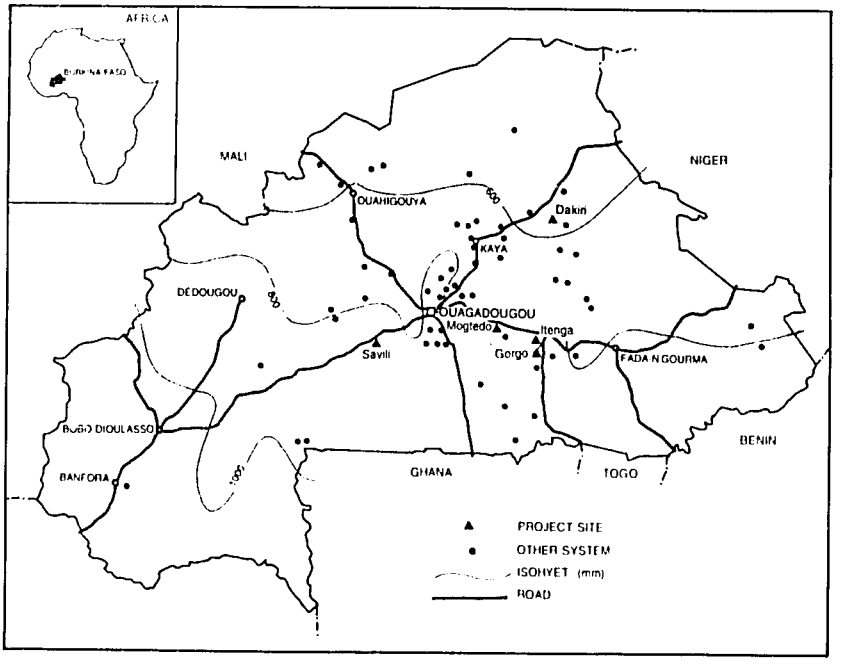
Though representing a good example of private enterprise, this expansion has been inequitable, causing tension between the privileged few and the majority.

The water resource is also abundant at Dakiri, opening the way for a similar expansion there. However, this has not yet occurred, probably because this scheme is relatively remote, with poor roads linking it to distant markets.

Average yields of rice exceeded 4 tonnes per ha at all schemes except Mogtédo (where they were probably underestimated). These yields represent 65–80 percent of the estimated potential. Several different rice varieties were used, but few farmers use certified seed.

Surveys of the Mogtédo and Itenga schemes during the dry season revealed extensive vegetable cropping. The dominant crop was onion, which accounted for 50 percent and 28 percent of the area cultivated to vegetables on the two schemes. At

*Figure 6. Distribution of small-scale, reservoir-based irrigation schemes and location of study schemes in Burkina Faso.*



Mogtédo, tomato and egg plant were also widely cultivated. The range of vegetables at Itenga was broader, encompassing egg plant, okra, tomato, cabbage and maize. At Savili, farmers mainly cultivated beans for export, but tomatoes were also grown. At Dakiri, almost no vegetables were cultivated, farmers preferring to cultivate rice during this season, presumably because it is easier to store and market. No dry season cultivation is possible in the Gorgo Scheme. Table 8 shows the water use efficiency at the Itenga and Gorgo schemes during the 1992 rainy season. The figures compare favorably with those for similar reservoir-based systems in north central Sri Lanka. Although the Burkinabè farmers are new to irrigated rice growing, they are not markedly less efficient than their colleagues in a traditional rice-growing society, belying the myth that Africans do not make efficient irrigators.

***Table 8. Returns to irrigation water in two study schemes (wet season, 1992).***

| Scheme | Reservoir releases (m3) | Paddy production[a] (kg) | Water use[b] per unit of land (m3/ha) | Water use efficiency | |
|---|---|---|---|---|---|
| | | | | kg/m3 | US cents/m³[c] |
| Itenga | 575,817 | 245,088 | 11,996 | 0.426 | 12.7 |
| Gorgo | 537,280 | 224,725 | 12,074 | 0.418 | 12.5 |

[a] : 5106 (kg/ha) x 48 (ha) in Itenga and 5050 (kg/ha) x 44.5 (ha) in Gorgo.
[b] : Rainfall has not been accounted for.
[c] : Calculated at 85 FCFA/kg of paddy, and US$ 1 = FCFA 285.

The schemes' performance in economic terms is shown in Table 9. The varying levels of annual farm income reflect the different cropping patterns and intensities. Net income is lowest (US$250) at Gorgo, where water shortages allow only a single wet-season crop of rice. It averages around US$375 at Itenga and Dakiri, where cropping intensities are

***Table 9. Average seasonal farm budgets in each study scheme.***

| Item | Dakiri (0.16 ha) | | Mogtédo I[a] (0.25 ha) | | Mogtédo II[a] (0.65 ha) | | Savili (0.25 ha) | | Itenga (0.22 ha) | | Gorgo (0.23 ha) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Wet season | Dry season | Wet season | Dry season | Wet season | Dry season | Wet season | Dry season | Wet season | Dry season | Wet season | Dry season |
| Percentage cultivated | 100% | 100% | 100% | 40% | 100% | 77% | - | 100% | 100% | 41% | 100% | - |
| **Costs (FCFA)** | | | | | | | | | | | | |
| Seed | ( | ( | | | | | - | 19,555 | 900 | 3,000 | | - |
| Fertilizer | (6,500 | (6,500 | 12,500 | 6,600 | 32,500 | 25,000 | - | 19,535 | | 10,750 | 11,140 | - |
| Pesticides | ( | ( | 2,500 | 1,200 | 6,500 | 5,000 | - | | 1,500 | 1,700 | | - |
| Wages | 1,000 | 1,000 | 15,000 | 10,000 | 54,000 | 25,000 | - | | 12,500 | | 10,000 | - |
| Land preparation (tractor) | 3,500 | 3,500 | 3,750 | 1,600 | 9,750 | 7,500 | - | 2,059 | | | 1,500 | - |
| Irrigation service fee | 0 | 0 | 4,225 | 1,000 | 10,985 | 5,000 | - | | 3,250 | 3,250 | 3,250 | - |
| Pump operation | | | | | | 40,000 | - | 11,670 | | | | - |
| Other charges | | | | | | 36,800 | | | 10,850 | | 500 | - |
| Total | 11,000 | 11,000 | 37,975 | 20,400 | 113,735 | 144,300 | - | 52,819 | 29,000 | 18,700 | 26,390 | - |
| **Income (FCFA)** | | | | | | | | | | | | |
| Paddy | 65,000 | 65,000 | 85,000 | | 221,000 | | - | | 93,500 | | 97,750 | - |
| Onion | | | | 120,000 | | 600,000 | - | | | 40,000 | | - |
| Tomato | | | | 20,000 | | 100,000 | - | 17,550 | | 5,000 | | - |
| Egg plant | | | | 6,000 | | 30,000 | - | | | 4,200 | | - |
| Okra | | | | | | | - | | | 1,990 | | - |
| Beans | | | | | | | - | 160,875 | - | | | |
| Cabbage | | | | | | | - | | | 7,700 | | - |
| Maize | | | | | | | - | | | 2,000 | | - |
| Total | 65,000 | 65,000 | 85,000 | 146,000 | 221,000 | 730,000 | - | 178,425 | 93,500 | 60,890 | 97,750 | - |
| Net income per holding (FCFA) | 54,000 | 54,000 | 47,025 | 125,600 | 107,265 | 585,700 | - | 125,606 | 64,500 | 42,190 | 71,360 | - |
| Net annual (FCFA) income per holding (US$)[b] | 108,000 | | 172,625 | | 692,965 | | 125,606 | | 106,690 | | 71,360 | |
| | 379 | | 606 | | 2431 | | 441 | | 374 | | 250 | |

[a]. Two categories of farmer are distinguished for the Mogtédo Scheme, representing normal farmers (Mogtédo I) and privileged farmers (Mogtédo II).
[b]1 US$ = 285 FCFA.

140 percent and 200 percent, respectively. At the other end of the scale are the privileged farmers of Mogtédo, who earn incomes of over US$2,000 a year, part of which is redistributed as wages and services. This class of farmers is emerging as the driving force in transforming irrigated agriculture from a subsistence activity to a commercial one with significance for national economic development.

IIMI's research also revealed the links between irrigated and rain-fed agriculture, the role of evaporation losses in limiting the potential for dry season cropping, and the importance of land tenure issues and the legal framework surrounding management turnover. These issues are discussed under Theme 4 (see page 44).

# THEME 3: IMPROVING PUBLIC IRRIGATION ORGANIZATIONS AND SECTOR-LEVEL MANAGEMENT OF IRRIGATED AGRICULTURE

Developing countries often suffer from long time-lags between the generation of new irrigation management technologies and their adoption by managers. The supply of innovations that, if used, would lead to improved performance runs way ahead of demand. The reasons for this problem are complex, but they are primarily to do with inappropriate policies and ineffective public organizations.

*Increased food production is a direct consequence of well-managed irrigation.*

Only rarely do government policies facilitate and encourage performance-oriented management, either at local or at higher levels of public irrigation services. Sector policies have frequently evolved as a series of ad hoc measures rather than being based on a systematic analysis of the range of possibilities and the trade-offs among different objectives. And when policymakers attempt to intervene, the processes of policymaking, implementation and assessment frequently prove defective.

Public-sector agencies often experience difficulty as they undergo reform. The case of the Office National des Aménagements Hydro-agricoles (ONAHA), in Niger, is typical (see Box ).

### PAINFUL ADJUSTMENT: THE CASE OF ONAHA

Created in 1978, the parastatal ONAHA is Niger's only irrigation agency. At first, it was responsible for both construction and management. It built new irrigation schemes, rehabilitated older ones and trained farmers in maintenance and field operations. Following a National Irrigation Conference in 1982, self-management by coopera-

tives was promoted and the role of ONAHA began to be redefined. Today, only a single ONAHA-paid Perimeter Director is assigned to each scheme as a technical adviser. For all other services, ONAHA charges cooperatives directly. Maintenance and repairs are charged at full cost, but training is partially subsidized.

For the past few years, ONAHA has faced increasing operational problems. It is now at crisis point. Funding for the construction of new schemes has all but disappeared. For political reasons, the agency has had difficulty in reducing its staff and operating costs.

The agency's traditional donors back major restructuring. They propose that the construction-oriented Enterprise branch of ONAHA be either privatized or liquidated. Provided this is done, several donors have pledged limited support for the service branch, which could continue to provide training and maintenance services to cooperatives.

Yet, if organizations and policies can be appropriately reformed, the rewards may be great. Past research by IIMI has shown that:

- Public agencies that are financially autonomous and dependent on users' fees for a significant portion of their income tend to have better performance levels.
- While the economic returns to constructing new systems have declined worldwide in recent years, the returns to projects combining modest rehabilitation or other physical improvements with the strengthening of irrigation institutions can be very high.

In this report we present three activities carried out under this theme in 1993. To check whether IIMI's current research program is broadly in line with sector needs, a brief study on global food supply and demand and the implications for research on irrigation management was conducted. Preliminary research on water markets in Pakistan considered the implications of a World Bank proposal on this subject. And a study on the institutional aspects of switching to crop-based irrigation in the rehabilitated Lower Swat Canal in Pakistan produced results with important implications for both donors and public-sector agencies.

## POLICIES

### Food Supply and Demand: Implications for Irrigation Research

A study completed in 1993 on global trends in food supply and demand confirmed the relevance of IIMI's current program to the long-term needs of the irrigation sector.

During the next century, the demand for food will continue to grow at 3 percent a year in large parts of the developing world. This rate will be sustained at least until the year 2025 in Asia, and probably for considerably longer in Africa and the Middle East. Most of the increases in the production of basic food staples will have to come from increased yields. This is particularly true of Asia, where there is little potential for increasing the area cultivated, especially that under irrigation. Average yields in this region will have to match the levels currently achieved in Japan if demand is to be met. In Africa and Latin America, there is still some potential for expanding the area under irrigation, but the costs of doing so will be too high for most countries. Almost throughout the developing world, increased reliance on irrigated agriculture will require much greater emphasis on improving irrigation management.

Among the research priorities identified by the study were several that are already central to IIMI's program. They include the assessment of irrigation performance, farmer participation in irrigation management, gender issues, the depletion of groundwater resources, the contamination of irrigation water, the problems of waterlogging and salinity, the competition for water between urban and agricultural uses, and the problems of equity and sustainability in large-scale systems.

### Encouraging the Development of Water Markets in Pakistan

A recent World Bank report advocates the development of water markets as a way of promoting greater efficiency in Pakistan's irrigation sector. The Bank's enthusiasm for this option rests on its apparent success in other countries (Chile and the USA) and on its general policy of privatization.

The term *water market* covers a wide variety of situations (see Box ).

#### WHAT IS A WATER MARKET?

Water markets vary according to the following characteristics:

### Object of transaction

When volumes of water only are traded, this is a lease or rental arrangement. This may be compared with the transfer of water rights, when the right of access to the water source changes hands.

### Use of traded water

Water may be transferred within a sector or between sectors. Since the agriculture sector accounts for the bulk of water use, most transactions between sectors involve a transfer from agriculture to industry or domestic use.

### Level of transaction

Water may be transferred between individuals, irrigation systems, public-sector organizations, private companies, provinces or countries, or any combination of these.

### Type of water

Groundwater or surface water may be traded. The special characteristics of the two kinds of water influence the organization of the market.

### Movement of water

Water may be exchanged between neighboring farms or transported by tanker over long distances. In the simplest transaction of all—the exchange of irrigation turns in a surface irrigation system—it remains in the same canal, merely leaving it at a different outlet.

### Mode of payment

Payment may be in cash or in kind. The latter may involve sharecropping, credit arrangements, or the provision of labor.

The past 20 years in Pakistan have seen the gradual development of water markets. Centered mainly on privately owned tubewells in the Punjab and the North-West Frontier Province, these markets operate largely at farm level and involve lease agreements rather than the transfer of water rights. In the wheat-cotton zone of the Punjab, some 35 percent of farmers are reported to be purchasers of tubewell water. Elsewhere in the country markets are more limited, with the occasional exchange of canal or public tubewell water being the predominant activity.

Markets tend to be highly localized, with most transactions occurring within the same watercourse command area. The dry summer months are the busiest period. Large landowners are the most active sellers, while purchasers tend to be tenant and small-scale farmers. Most arrangements are bilateral, i.e., there is no middleman.

In areas where the quality of groundwater is good, farmers at the tail end of watercourses, who often receive little or no canal water because of the poor performance of the surface irrigation system, frequently sell their canal water turns to farmers at the head end.

In some areas, transactions are paid for mostly in cash, but in others sharecropping or credit arrangements exist. Occasionally, water is exchanged for

labor, or against the rent owed by tenant farmers. Prices vary greatly, from PRs 12 to PRs 80 (US$0.40–3.33) per hour of water application.

Little is known about the impact of Pakistan's water markets on the quality of irrigation services, on agricultural production and on the environment. Water purchases generally have a positive impact on cropping intensity, yields and gross farm income. The impact on yields appears variable, however, with some studies reporting that water purchasers had lower yields than tubewell owners.

Allowing market mechanisms to redistribute water should, in theory, promote its more efficient use. It should also increase the flexibility of supplies, enabling demand to be met more fully and accurately.

Under the World Bank proposal Pakistan would:

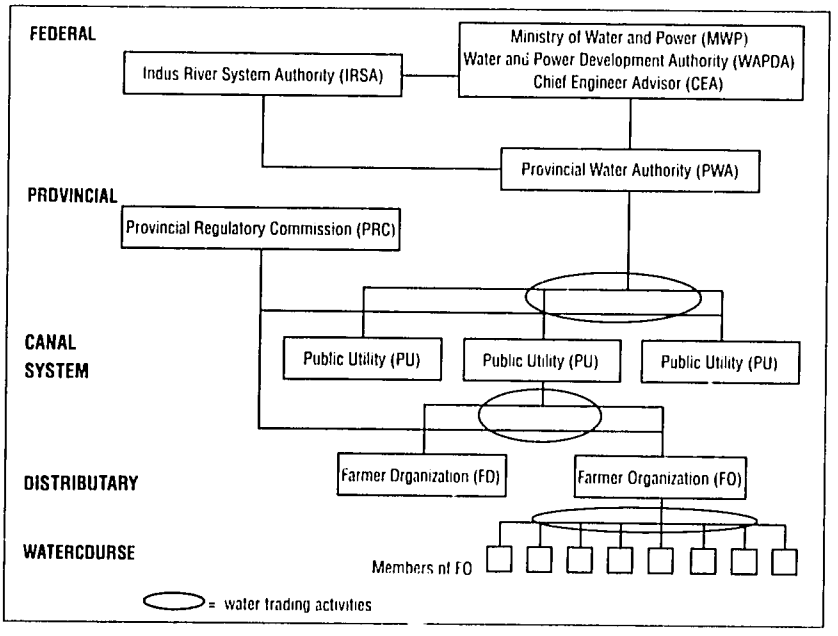
- Formalize water markets and define individual water property rights.
- Restructure the agencies responsible for operating irrigation systems as public utilities (one for each canal command area).
- Promote the development of strong farmers' organizations.
- Form new government agencies to manage water resources at provincial level and regulate the activities of the utilities and farmers' organizations.
- Strengthen agencies at federal level so that they implement their current responsibilities more efficiently.

These proposals are summarized in Figure 7, which shows the institutional structure put forward by the World Bank. Water transactions would develop at three levels: between public utilities, between farmers' organizations and between individual members of farmers' organizations. To ensure financial viability, expenditures on investments and on operations and maintenance at each level would be recovered from the level below. One task of the utilities would be to facilitate water trading between farmers' organizations.

The public utilities would have real autonomy, a hard budget constraint and a mandate for self-sufficiency. In the longer term, they would be privatized by selling the government's equity to private shareholders.

Table 10 on page 35 compares Pakistan's existing water markets with the institutionalized and fully developed water markets described in the World Bank proposal. There are several important differences. First, the World Bank proposal focuses on the transfer of water rights, whereas existing markets involve lease agreements. Second, the scale of operations under the World Bank proposal is considerably greater, involving watercourses, distributaries and main canal levels. The current market operates at watercourse level only. Third, the World

***Figure 7. Institutional structure and potential for water markets in Pakistan according to the World Bank proposal.***



Bank proposal covers canal water only, taking no account of conjunctive use. Yet 40 percent of supplies under the current system come from public and private tubewells. And fourth, only the quantity of water is considered by the World Bank. Characteristics such as quality and reliability have been omitted, despite strong evidence that these influence the price of water.

*Table 10. Comparison of existing with proposed water markets.*

| Characteristic | Current water markets | Proposed water markets (World Bank) |
|---|---|---|
| Main source of traded water | • Mainly private tubewell water in Punjab and NWFP<br>• Mainly canal water in Sind | • Focus on canal water (tubewell water not mentioned in the proposal) |
| Level of water trading activities | • Localized, mostly within watercourse command area | • At 3 levels: among public utilities (main canal), among and within farmers' organizations (distributary)<br>• Watercourse markets not mentioned although they are functioning |
| Institutional arrangements | • Informal water lease agreements<br>• No established water rights (or rights linked de facto with land ownership) | • Formal watar rights<br>• Regulated and controlled by various institutions<br>• Functioning farmers' organizations a pre-condition for success |
| Control of external effects | • Few external effects as transactions are local<br>• External effects not considered | • Various institutional arrangements to control external effects<br>• Problems of enforcement expected |
| Transaction costs | • Very low<br>• Included in other socio-economic relationships (landlord, tenant etc.) | • Costs of new infrastructure required for operations and accountability<br>• Very high information costs |

The most serious reservations regarding the World Bank proposal must be leveled at its institutional assumptions. Despite the failure of all past attempts to introduce water users' associations in Pakistan, the proposal assumes that these can be formed and sustained. It is also optimistic in its belief that current irrigation bureaucracies at provincial and federal level can be reformed. IIMI's experiences dictate a more sober assessment.

IIMI's preliminary study concludes that the differences between the existing and proposed water markets are so great that analyzing the effects of the current water markets does not provide a basis for predicting the impact of the World Bank proposal. The impact on equity is particularly difficult to forecast.

## MANAGEMENT

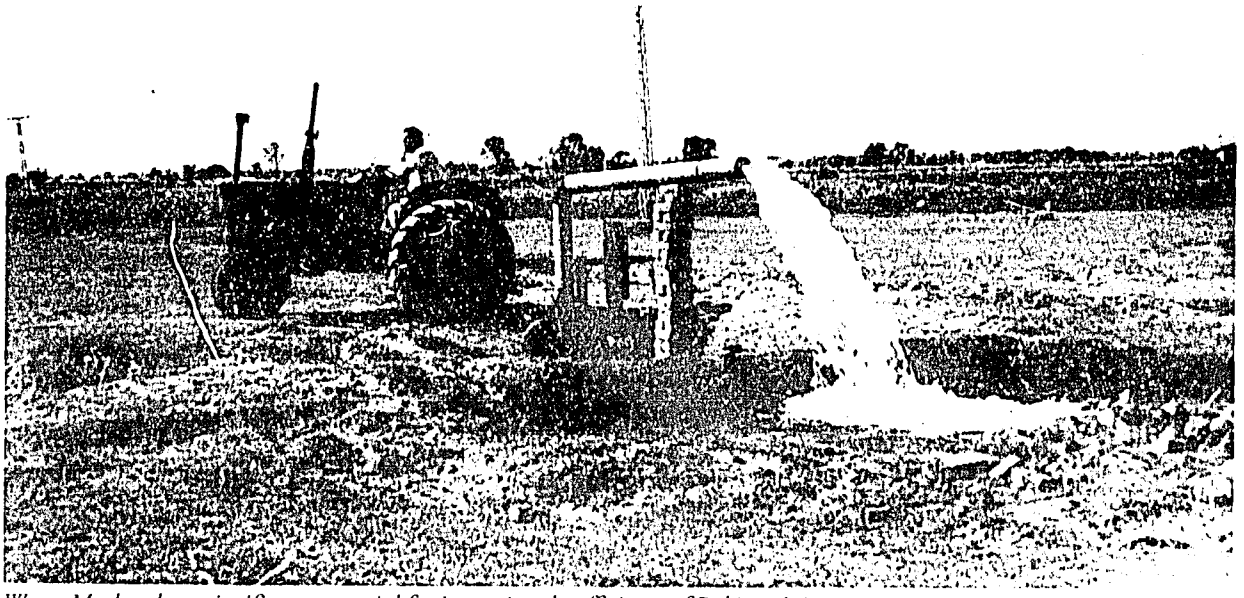
### System Modernization in Pakistan: A Missed Opportunity

During the 1980s, the Lower Swat Canal Irrigation System in the Mardan District of Pakistan's North-West Frontier Province underwent extensive remodeling.

The system's original design, conceived by the British in 1870, kept operational requirements to a minimum. It was a supply-driven, run-of-the-river system with few control structures on the canal. The distributaries either ran at full to near full supply levels, or were shut down completely to avoid siltation. Field outlets were not gated but instead had structures known as *moghas*. These acted as proportional flow distributors, taking less when the canal level was low and more when it was high.

By the early 1970s, the system was experiencing a shortage of water to meet its rapidly increasing cropping intensity. In addition, siltation had become severe, leading to canal overflows, waterlogging and inequitable distribution in the lower reaches.

Remodeling the canal to increase its capacity provided the opportunity to switch to crop-based irrigation, which promised large gains in production. This change was seen as essential, since if the supply-driven operational system were to continue after



*Water Markets have significant potential for increasing the efficiency of Pakistan's irrigation sector.*

capacity had been enlarged, considerable inefficiency in the use of water would result, aggravating existing drainage problems and leading to increased water-logging and salinization.

The switch had several design implications. The most important was the need to replace the *moghas* with gates. These would be needed to adjust the three elements of any demand-based system—the rate, duration and frequency of water applications.

It was, however, recognized that the switch to crop-based operations could not happen overnight. Both agency staff and farmers would have to be prepared to take on greater responsibility—including responsibility for gate operations. The final project plan therefore proposed to install adjustable proportionate modules similar to those already used, but with a modification in design that would allow later conversion to gate operations. In the interim the new outlets were to be manually operated by a gauge reader, rather than functioning automatically as in the past.

Escapes were to be provided to reroute excess water back to the river for use further downstream. This feature was critical for river avoiding siltation problems, since it meant that the canal could be operated at full capacity in the interim. The escapes would also allow sections of the canal to be emptied for maintenance. The use of escapes meant that control structures could be kept relatively simple and few in number, departing little from the system's original design.

The management implications of the change to crop-based operations were not considered in the initial project planning report. This was left to the operations manual, which described in some detail the procedure for ordering and delivering water (see Box).

## OPERATING THE REMODELED SYSTEM: PROCEDURES ACCORDING TO THE OPERATIONS MANUAL

The chairman of the water users' association for a given watercourse would collect written water orders from users 48 hours in advance, handing them to the gauge reader or placing them in a small metal receptacle mounted on the outlet gate. The gauge reader would pass orders to the subengineer, who would hand them to the engineer. The latter would have a water despatch officer on staff, who would use a desk-top computer to schedule

deliveries throughout the system. The completed delivery schedule would be sent back to the subengineer and then to the gauge readers.

The gauge reader would regulate the gate in accordance with the schedule, entering the amounts ordered and delivered in a daily record book.

The distribution of water in the watercourse would be the responsibility of the water users' association, with the entire flow being used by one farmer at a time, as in the past. This would allow each farmer to compute the depth of water applied to each field, enabling him to evaluate his irrigation practices and maximize their efficiency. The Irrigation Department and the water users' associations would be jointly responsible for guiding farmers in their cropping patterns to ensure that peak demand did not exceed capacity.

The chairman would be recompensed for his services through fees levied on members of the users' association.

The manual also proposed that a small distributary branch or minor should be selected by the Irrigation Department to demonstrate the crop-based system. This would serve as a training ground for agency staff and farmers.

The first sign that the switch to crop-based irrigation was in trouble was that the Irrigation Department dragged its heels in implementing this proposal. Joint missions by the donors from 1988 to 1990 repeatedly underlined the need to make progress in training and demonstration. Eventually, a small area of experimental plots was begun. Its expansion to the 120 ha originally envisaged was twice urged, but to no avail. In the end, the donors had to acknowledge defeat, conceding that the pilot scheme would not benefit this project but future ones. An appraisal report of 1991 notes, "an attitude of skepticism" towards the crop-based irrigation approach on the part of agency staff.

To make matters worse, the construction agency put in place a physical system that implied an immediate switch to crop-based operations, ignoring the cautious approach of the project plan. Instead of modified adjustable proportionate modules, gated pipe outlets were installed, requiring constant adjustment. The escapes needed for the interim were not constructed. And despite the aim to keep control structures to a minimum, these were provided at all points of diversions and at the drop structures.

Not surprisingly, these new design features, for which neither farmers nor agency staff were adequately prepared, soon led to trouble. Farmers in the head reaches of one distributary reacted to the new gated outlets by opening them to the maximum, helping themselves to the full supply. This meant that tail-end farmers did not receive enough water during the peak demand period and had to resort to irrigating at night. Staff of the Irrigation Department then took control of the gates by locking them. Angry farmers reacted by tampering with the gates and, in some cases, damaging them.

These incidents led the Irrigation Department to ask the construction agency not to install the remaining gated outlets and to take out those already installed. The department was prepared to store the outlets and to install them when conditions became suitable. This, it felt, would only be the case once training and demonstration had paved the way for the introduction of crop-based irrigation, as envisaged in the operations manual. The present mood of management in the Irrigation Department can be described as one of frustration and helplessness.

What went wrong? An investigation by IIMI concluded that the decision to install different structures to those envisaged in the project plan had been taken without proper consultation. It was based on the false assumption that farmers and agency staff were sufficiently organized and knowledgeable to undertake an immediate switch to crop-based irrigation.

The crop-based system had been an attractive idea in the minds of the planners at the project design stage. Unfortunately, it had remained just that. The failure to realize the implications of its introduction to a deeply rooted supply-oriented institutional culture had led to a half-hearted approach, with little attempt to sell the idea to others and to make the necessary institutional and training arrangements. Communication between the construction agency and the Irrigation Department had been poor throughout the project, with the energy and attention of project staff being almost entirely devoted to construction aspects. Worse still, there had been little contact with farmers, who were not represented on the Project Management Committee. The water users' associations whose role is described in such detail in the operations manual do not even exist!

In short, substantial efforts had gone into the physical remodeling of the system, without a corresponding input into its institutional remodeling. The main reason for this missed opportunity to introduce crop-based irrigation was the failure to make institutional change a specific objective of the project. In the words of Arturo Israel, "since institutional development is everybody's business, it often becomes, in practice, nobody's business."

# THEME 4: LOCAL MANAGEMENT OF IRRIGATION

The management of irrigation by farmers is now known to be far more widespread than was thought 10 years ago when IIMI was founded. For instance, the proportion of irrigated area under farmer management is estimated at 67 percent in Nepal, 64 percent in India, and 63 percent in the Philippines. Moreover, this area is increasing rapidly as more and more countries adopt policies to hand the responsibility for operation and maintenance over to locally established water users' associations. This process of management transfer or turnover is itself a strong determinant of the subsequent performance of farmer-managed irrigation systems.

Accordingly, IIMI's research under this theme has two major components—farmer management and the turnover process. Under the former, IIMI investigates the performance of systems managed either exclusively by farmers or jointly between agencies and farmers, and asks how farmer management can best be supported by governments. Under the latter, the focus is on the process of turnover itself—the approaches used in different economic and social settings, and their outcome. In both cases, IIMI analyzes and compares experiences in different countries, in an attempt to draw out the lessons for managers and policymakers. Given the pace of change in this field, the emphasis is on the rapid exchange of information and research results using a networking approach.

This year we report on only a small selection of IIMI's many projects dealing with the local management theme, most of which are still in the midst of data collection or at the early stages of data analysis.

Under the turnover component we begin with an account of Nigerian experience in the formation of water users' associations, a critical part of the turnover process in situations where farmers have traditionally lacked strong social institutions. Next we turn to Indonesia, where farmers are facing high irrigation costs following the turnover of pump irrigation systems. Lastly, we look at two irrigation districts in Colombia, where management was transferred nearly 20 years ago. These systems may provide valuable insights into the long-term effects of turnover, as well as lessons for the governments as

*The water users' association in the Kano River Irrigation Project, Nigeria, continues to receive assistance from IIMI.*

management turnover once again rises to the top of the political agenda.

Under the farmer management component, we explore the complex of social and technical issues surrounding the performance of reservoir-based irrigation systems in Burkina Faso. Unlike in Asia, irrigation in the African Sahel is closely linked with rain-fed agriculture—a factor which critically affects its resource allocations and profitability. Next we turn to research in Bihar State, India, where IIMI has examined the extent of conjunctive use of groundwater and surface water, a strategy to which farmers increasingly resort when agency supplies of surface water prove unreliable. We end the thematic section of this report with an overview of preliminary work on the analysis of gender issues in irrigation, an important topic that cuts across all IIMI's programs but has its intellectual home under the local management theme.

## THE TURNOVER PROCESS

### Forming Water Users' Associations in Nigeria

Experiences around the world reveal several features that promote the establishment of strong water users' associations. These include guaranteeing them water rights, providing them with the status of a legal entity, ensuring secure land tenure for farmers, and using tenure as the basis of membership of an association. IIMI's research in Nigeria has confirmed that this set of conditions is conducive to success.

During 1993, studies continued on the establishment of water users' associations in the Kano River Irrigation Project (KRIP), in the north of the country. The KRIP System forms part of the larger Hadejia-Jama'ara River Basin Development Authority (HJRBDA), one of eleven such authorities in Nigeria. The three pilot sites selected for the study are Bangaza, in the head section of the system, Agolas, in the middle section, and Karfi, in the tail. The sites represent about 4 percent of the total irrigated area of KRIP and cover some 4.5 percent of the project's farm families.

At the start of the project there was considerable discussion among participants as to whether the geographical unit selected as the basis for forming water users' associations should be the village or the command area of the distributary canal. In the end the command area was chosen as the more practical alternative. Villagers may belong to different distributary canals and so would not have the same

water source as a unifying factor in planning and implementing activities. Choosing the command area as the criterion overcame this difficulty. In addition, the command area allows the hierarchical 'nesting' of associations at different levels, from distributary canal up to main canal level.

The first step was to prepare maps showing all individual plots within the boundary of each association. The maps provided information on the size of each holding and the names of landholders. A rapid appraisal method was used to collect these data.

Water users' associations are not kick-started, but are allowed to evolve at their own speed. Farmers are encouraged to take their time and think through the implications of having an association before committing themselves. KRIP and IIMI staff act as facilitators rather than organizers.

Farmers at Agolas organized themselves quickly and effectively. Staff began by visiting farmers in their fields on several occasions, to talk about the need for a water users' association. Next, a group of farmers called a meeting to discuss the issue more formally. After four or five meetings of this kind an ad hoc committee was formed to carry out the association's activities until it was officially registered.

Farmers in other villages followed suit. Those in Bangaza were rather slow in starting, becoming active only during the dry season of 1992/93, but they have since made rapid progress in organizing and implementing maintenance activities.

The formation of water users' associations has already had an impact on irrigation performance in several key areas (see Box ).

## PERFORMANCE IMPROVEMENTS IN THE PILOT AREAS

### Physical improvements to infrastructure

In Bangaza, the association cleaned 70 percent of the distributary canal and 60 percent of field channels during the dry season of 1992/93. In Agolas, during the same season the figures were 40 percent of the distributary canal and over 80 percent of field channels (see Figure 8 on page 41).

### Improvements in hydraulic performance

Measurement of the flow before and after cleaning in Agolas showed a 12 percent increase in water in the middle and tail sections of the distributary canal. Similar results were achieved in Bangaza and Karfi. These improvements in performance led to time savings for irrigators, who were able to irrigate their fields more quickly. Tail-end farmers found they no longer had to irrigate at night.

### Higher collection rates for water charges

Because farmers rather than agency staff now collect water charges, it has become less socially acceptable for farmers to refuse to pay. The Bangaza users' association has claimed a 90 percent success rate.

Visits between associations were instrumental in stimulating progress. In 1993, the farmers of Agolas and Karfi visited those of Bangaza and were greatly impressed by what they saw. In the words of the IIMI staff member who organized the visits, "Farmers immediately recognize the problems encountered and the solutions found. Peer group pressure hits the ego and promotes rapid learning. Visiting farmers feel: 'If they can do it, why not we?'"

Some water users' associations have extended their activities beyond operation and maintenance. The major area of additional involvement has been the collection of water charges, but activities have also been noted in such areas as marketing, input supplies and tractor hiring. One association has introduced punishments for the cutting of bunds to irrigate fields illicitly.

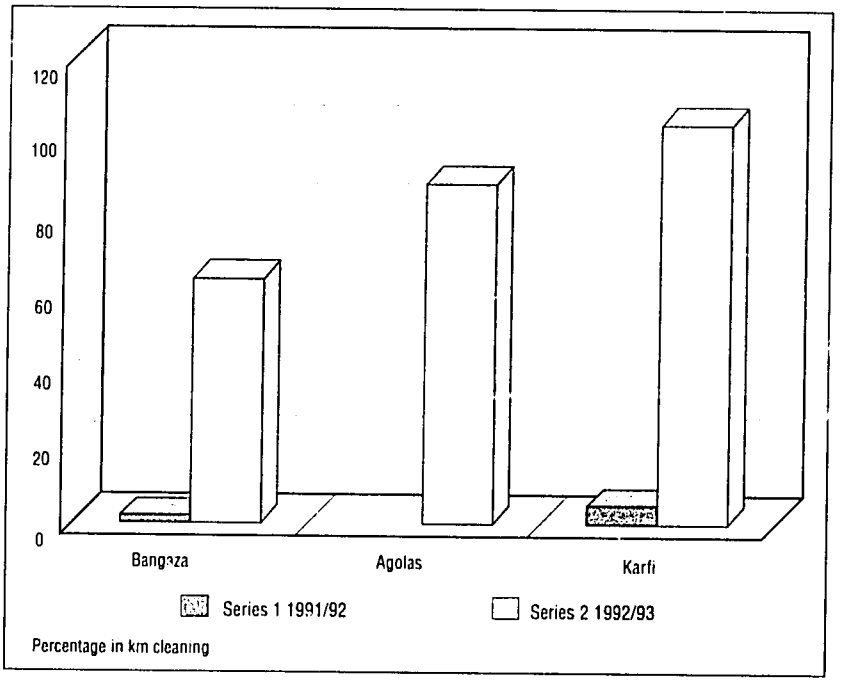
HJRBDA is now providing strong institutional support to the project. The authority has established units both at its own headquarters and within KRIP to promote and sustain new associations. It has also

established a review committee to monitor the units' activities. KRIP has assigned 12 staff members to encourage the formation of associations throughout the system. In some cases, users' associations are now officially registered; in others, an agreement between the association and the agency on the sharing of responsibilities has been signed.

The keen interest of the Managing Director of HJRBDA has helped both farmers and agency staff grasp the seriousness of the authority's commitment. Senior agency staff and farmers have engaged in a lively dialogue that includes the use of radio interviews and news bulletins.

The Board of HJRBDA has authorized the new associations to collect water charges on behalf of KRIP on a trial basis. Provided the association collects 90 percent or more of the total due for its area, it is permitted to retain 15 percent of the amount collected. It can use this sum to repair and maintain structures within the distributary command area. The Bangaza users' association is the first to put this new arrangement to the test, having requested KRIP to return 15 percent of the sum it submitted.

*Figure 8. Field channel cleaning by three water users' associations.*




In the short term, maintenance and operations above the distributary channel level will remain the responsibility of KRIP. Eventually, however, farmer management will be extended to higher levels of the system.

Success at the pilot sites has prompted KRIP to expand activities to nine other distributaries. A second project under the HJRBDA, the Hadejia Valley Project, has started a pilot users' association at Gamsaka. The Wurno Irrigation Project, funded by the Commission of the European Communities, is following a similar procedure in forming its own associations.

## Counting the Cost: Pump Irrigation in Indonesia

With the potential for expanding gravity irrigation more or less exhausted, the Government of Indonesia has turned to the development of groundwater irrigation through the introduction of pumps. Increasing agricultural production through pump irrigation is particularly important in the drier and poorer areas of Eastern Indonesia.

The government has provided generous assistance, drilling wells free of charge, giving pump sets to farmers, building water distribution systems with minimum investments by farmers, and subsidizing agricultural inputs.

Two organizations under the Directorate General of Water Resources Development are primarily responsible for executing the government program. They are the Sub-Directorate of Groundwater Planning (P2AT), which undertakes construction activities, and the Sub-Directorate of Groundwater Development (PAT), which operates and maintains wells on an interim basis, assists in the establishment of water users' associations, and

monitors cropping patterns and crop production. After the first 2 years, P2AT hands over the responsibility for operation and maintenance to the local government, which in turn expects the water users' association to take charge. However, despite formal transfer, P2AT continues to provide assistance with pump operators' salaries and maintenance of the equipment.

The water users' associations have been highly effective at collecting irrigation fees. Most operators claimed complete or near-complete collection rates. Sanctions are applied for nonpayment. In one system, only half the farmers paid the fee at first, but the rest followed suit when the executive committee cut off their water supplies. However, most users' associations are not building up savings as planned, often because of mistrust and squabbling between committee members.

***Table 11. Typical water costs per hectare per season for pump irrigation at selected research locations.[a]***

| Province/Area | East Java Nganjuk/ Kediri | Madura South and East | West Jawa Subang | Yogyakarta C. Kidul |
|---|---|---|---|---|
| *Wet season* (rice) | | | | |
| Maximum | | | | |
| US$/ha | 13.44 | 36.18 | 40.10 | 24.02 |
| Rp/ha | 25,542 | 68,750 | 76,187 | 45,630 |
| Minimum | | | | |
| US$/ha | | | | |
| Rp/ha | [b] | | | |
| *Dry Season* 1 | | | | |
| Maximum | | | | |
| US$/ha | 52.40 | 52.63 | 71.31 | 46.67 |
| Rp/ha | 99,569 | 100,000 | 135,484 | 88,667 |
| Minimum | | | | |
| US$/ha | 3.19 | 28.94 | 33.73 | 3.20 |
| Rp/ha | 6,056 | 55,000 | 64,081 | 6,077 |
| *Dry Season* 2 | | | | |
| Maximum | | | | |
| US$/ha | 51.17 | 65.50 | No Pumping | 58.14 |
| Rp/ha | 97,229 | 124,444 | | 110,467 |
| Minimum | | | | |
| US$/ha | 9.81 | 17.91 | | 15.79 |
| Rp/ha | 18,638 | 34,028 | | 30,000 |
| *Dry Season* 3 | | | | |
| Maximum | | | | |
| US$/ha | 51.97 | No Pumping | No Pumping | 48.95 |
| Rp/ha | 98,750 | | | 93,000 |
| Minimum | | | | |
| US$/ha | 39.47 | | | 11.81 |
| Rp/ha | 75,000 | | | 22,440 |

[a]Based on the averages for all the pumps surveyed in the area. Exchange rate=Rp1900=US$1.00
[b]Farmers making a payment of Rp 0 did not irrigate but grew a rainfed crop.

Water fees are now high, accounting in some cases for up to 55 percent of farmers' input costs. As Table 11 shows, a farmer growing three crops a year could end up paying over US$132 per ha, although the average is more likely to be US$53–79. The main component of fees is the cost of fuel to power the pumps.

Faced with these costs, farmers have reduced their use of pumped groundwater. Pumping hours have declined since turnover. Average cropping intensity seldom exceeds 170 percent—a far cry from the 300 percent predicted by planners. And most pumps are not serving the full command area for which they were designed.

The high costs of irrigation have hit resource-poor farmers in the eastern islands particularly hard—the very area the government intended to benefit most by its program. Here farmers lack the resources to prepare land properly and to buy other inputs such as improved seeds and fertilizer. Under these circumstances, the use of pumped groundwater to stabilize production conditions becomes far less attractive. Even in higher potential areas, farmers are still reluctant to invest in water owing to the lack of credit facilities.

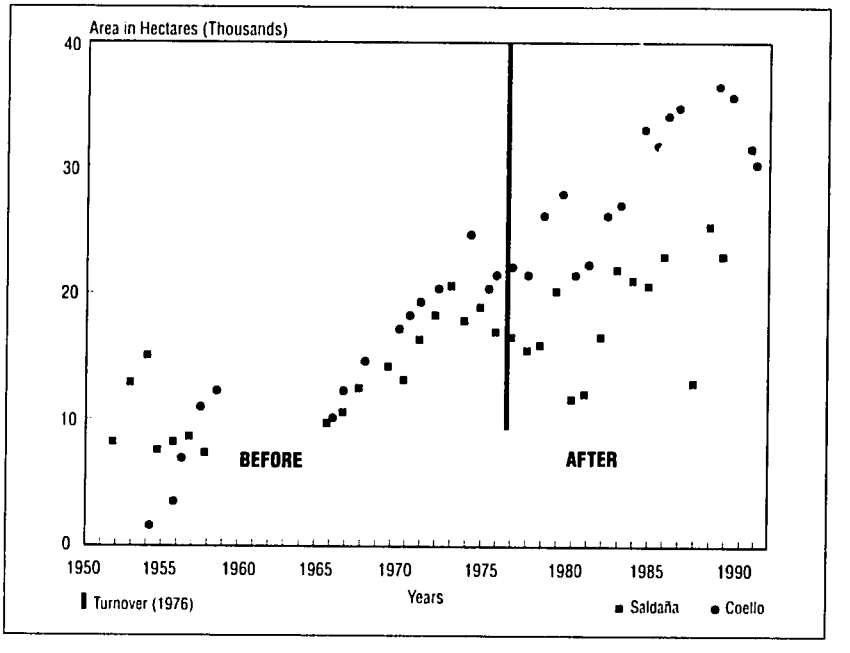
Even with such high water fees, farmers are paying only for operation and maintenance, contributing little or nothing to capital replacement costs. If in groundwater exploration, payments to contractors and interest are added, the real costs are often three to five times what farmers are paying. Assuming the average farm size is 0.5 ha, government assistance amounts to a welfare payment of approximately US$100 per farm family per year.

A major shortcoming has been the installation of systems far beyond the resources of users. In many cases, the turbine pumps and large imported diesel engines used have proved too sophisticated,

requiring spare parts and tools not available in the area and sometimes not even in the country.

The study concluded that when all the costs of development are included, pump irrigation in Indonesia has yet to prove itself economically viable. The extensive involvement of outside consultants and excessively high installation costs compared with those of other countries in the region have pushed development costs beyond the level justified by the returns to agriculture. Only in limited areas where high-value crops such as tobacco and shallots can be grown does pump irrigation appear justified.

***Figure 9. Irrigated area before and after management turnover in Saldaña and Coello districts, Colombia.***




## Learning from Early Experience: Turnover in Colombia

Colombia's experience in management turnover predates that of most other developing countries. Operation and maintenance in the districts of Coello and Saldaña were handed over to reorganized water users' associations as early as 1976. During the deep economic recession of the 1980s, the process of turnover came to a halt. Now it is getting under way again, spurred by the recovery of the 1990s and the policies of economic liberalization espoused by the government. The performance of irrigation under farmer management in Coello and Saldaña is therefore of special interest, providing potentially valuable lessons as the government now seeks to promote and facilitate turnover in other areas of the country. IIMI is assessing performance before and after turnover and reviewing the transfer process.

Initial results suggest that system operation and maintenance have neither improved nor deteriorated significantly since transfer. After a temporary downturn immediately following transfer in 1976, the area irrigated has continued to expand, indicating that farmers have confidence in the system's ability to deliver water (Figure 9). Rice yields have stabilized since transfer, while those of cotton have continued to increase.

Both farmers and agency officials agree that paperwork and bureaucracy have been cut back considerably since transfer. Processes such as requesting water and paying irrigation fees have become simpler, and the agency is reported to have become more accessible to users. On the other hand, no formal evaluation process is in place in most systems—a dangerous economy if, as research elsewhere suggests, such a process is essential for improving performance. The emphasis on cost cutting has led to a decline in real terms in the irrigation fees levied by users' associations, although there have been considerable fluctuations from one year to the next (see Figure 10 on page 44).

Occasionally, the Boards that oversee water users' associations appear overzealous in their pursuit of efficiency gains, replacing experienced with inexperienced staff and merging or eliminating key positions. Significantly, little investment is made in training and in replacing equipment. Most Board members lack formal training in irrigation management, and some intervene too much in the everyday operations of the associations.

Users feel strongly that the government agency should not cut its ties with the users' associations completely. They still hope that the government will rehabilitate and expand the irrigation systems at no cost to themselves*

## FARMER MANAGEMENT

### Rain-Fed versus Irrigated Agriculture in Burkina Faso

In many farming communities—and especially those in sub-Saharan Africa—irrigated agriculture is not a full-time occupation, but must compete for labor and other inputs with rain-fed production. This is the case in Burkina Faso where, in 1993, IIMI continued its diagnostic studies on the farming systems associated with five small-scale reservoir-based irrigation systems. Findings on the productivity of these systems have already been reported under Theme 1.

#### *Links between the subsectors*

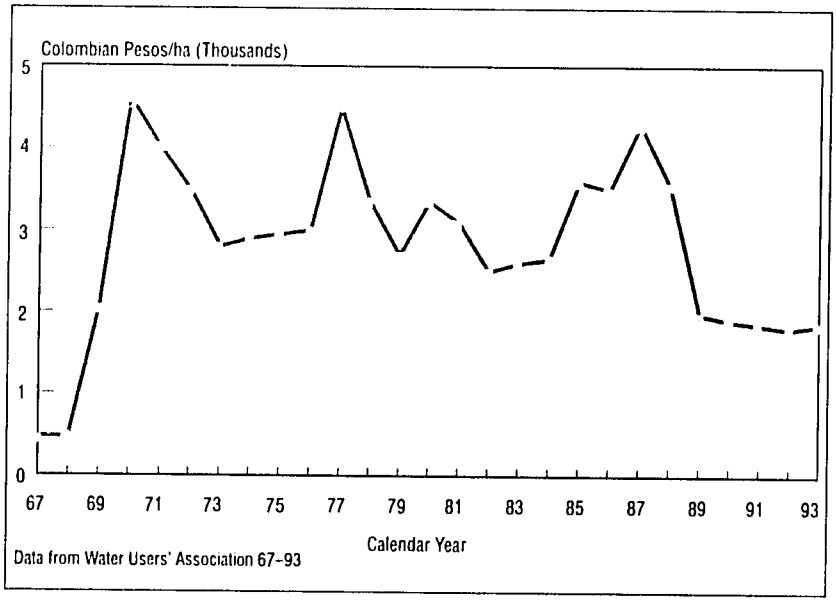
Dependent on brief and unpredictable rainfall, rain-fed farming usually takes precedence over irrigated production. Because of the security offered by the stored water, farmers consider delaying the start of the irrigation season to be less risky than sowing rain-fed crops late. Insufficient labor and the lack of farm power are further constraints to the simultaneous practice of irrigated and rain-fed agriculture. Delays in irrigating lead to excessive losses of stored water due to evaporation.

Due to the small amount of land allotted to each family (0.08–0.30 ha), the total production from irrigated holdings is low compared to that from rain-fed holdings, which may extend to 4 ha or more. The productivity of irrigated land, in contrast, is high—sometimes 10 times that of rain-fed land, where poor soils and low and unpredictable rainfall severely constrain yields.

Table 12 on page 45 presents a typical example from the Dakiri Irrigation Scheme. The irrigated land represents only 5 percent of the total family holding, but its higher yields result in total production being nearly equal to that of the rain-fed land. Produce from the rain-fed land meets over 80 percent of the family's cereal needs. Irrigated agriculture provides the balance, with this region's nonrice-consuming farmers selling their rice and buying millet and sorghum with the proceeds. In spite of its higher labor demands, the returns to labor are nearly three times greater in irrigated than in rain-fed farming. However, the limited size of irrigated holdings does not allow farmers to rely entirely on these to meet their food requirements and provide a satisfactory income.

This presents policymakers with a difficult choice between equity and growth objectives. Increasing the size of holdings appears economically desirable but would help to create a few, highly privileged farmers of the kind already found at Mogtédo (see page 29). Keeping the size of holdings at or below its present level would spread the benefits of irrigation among a larger number of people, but would probably reduce profitability. The demand

*Figure 10. Irrigation fees in the Coello Irrigation District (fixed tariff per hectare in constant 1988 pesos).*



*Farmer-managed systems constitute more than half of the total irrigated area in countries like Nepal.*

for irrigated land is high. At Dakiri, for example, there is a waiting list of nearly 900 applicants in addition to the existing 750 beneficiaries.

To justify investment costs, irrigation should be able to provide farmers with a profitable, full-time occupation. For as long as it fails to do so, farmers will spread their risks by simultaneously pursuing rain-fed agriculture and other activities. If, as seems likely, holding size cannot be increased, farmers must be encouraged to invest in their irrigated holdings so as to increase productivity. This highlights the need to provide secure tenure through implementation of the 1991 land reform act (see page 47).

### Relationship between profitability and size of reservoir

One of the project's most interesting findings concerns the possible link between size of reservoir and profitability of irrigated agriculture. Figure 11 on page 47 compares net annual returns per unit of land to the relationship between water storage and command

**Table 12. Returns to rain-fed and irrigated agriculture on the Dakiri Scheme.**

| | Area cultivated (ha) | Yield (kg/ha) | Production Total (kg) | Production Percent | Labor input (hours)[a] | Productivity (kg/hour) | Costs (kg) | Family consumption (kg)[c] | Net income (FCFA) |
|---|---|---|---|---|---|---|---|---|---|
| Rain-fed farm, 2.8 ha (95 % of the total family landholding) | | | | | Labor input for rainfed farming | | | Basis of calculation = 220 kg per person per year | |
| - Millet/sorghum | 2.26 | 650 | 1,469 | - | | | | | |
| - Groundnut | 0.36 | 550 | 198 | - | = 840 h/ha | | | | |
| - Maize | 0.18 | 700 | 126 | - | | | | | |
| Total rain-fed area | 2.80 | - | 1,793 | 53% | 2,352 | 0.76 | 0 | 2200 kg for a family of 10 persons | Marketable surplus = 3393 - 260 - 2200 = 933 kg |
| Irrigated farm, 0.16 ha (5 % of the total family land-holding) | | | | | Labor input for irrigated rice = 2,300 h/ha | | Costs per season[b] = 11000FCFA = 130 kg paddy @ 85F/kg | | 933 kg @ 85 F/kg = 79305FCFA |
| - Wet-season rice | 0.16 | 5,000 | 800 | | | | | | |
| - Dry-season rice | 0.16 | 5,000 | 800 | | | | | | |
| Total irrigated area | 0.16 x 2 | - | 1,600 | 47% | 736 | 2.17 | 260 | | |
| Total family landholding | 2.96 | - | 3,393 | 100% | 3,088 | 1.10 | 260 | 2,200 | 79,305 FCFA (US$ 278) |

[a] Source of labor input data : Projet Sensibilisation (1991) for rain-fed crops and Dembélé (1988) for irrigated rice.
[b] Inputs = 6,500 F ; other costs = 4,500 F.
Total costs for irrigated rice = 11,000 F/season = 130 kg paddy.
Costs related to rain-fed farm = 0.
[c] Basis of calculation: cereal needs = 220 kg/person/year, or 2200 kg for a family of 10 persons.

area for each scheme. The more water is stored, the higher the cropping intensity and the more productively land is used. This relationship is closely connected with the problem of losses caused by evaporation (see Box ).

*Farmer-managed tubewells are an important component of irrigation.*

### EVAPORATION: A KEY CONSTRAINT

Evaporation losses from reservoirs are particularly high in Burkina Faso, where the dry season is long, temperatures extremely high and reservoir sites are flat. At the Itenga reservoir nearly two-thirds of the stored volume is lost to evaporation between 1 October and 30 April. With deductions for domestic and livestock use, even less water is left for dry-season cropping.

Some dry-season cropping is necessary if farmers are to obtain good returns from irrigation. The project's findings so far suggest that dams with a relationship between storage capacity and command area of 5 or more cubic meters for every square meter of land can support 40–50 percent vegetable production during the dry season. (This may also represent the upper limit of activity which farmers are prepared to undertake: horticulture is labor-intensive, and is unlikely to be conducted as extensively as cereal production.)

When Mogtédo was first constructed it had a relationship between storage and command area of 7.05 cubic meters per square meter. The spontaneous expansion of cultivation around this scheme can thus be seen as a "grass roots" response to the perception that resources were being wasted. The scheme has been adjusted by its users so that it is now nearer its optimum size, with a relationship between storage and command area of 53,330 $m^3$ per hectare (or 5.33 cubic meters per square meter).

As long as a cropping intensity of 40 to 50 percent during the dry season is possible, most of those who wish to practice horticulture will be able to do so on some part of their land. Intensities are likely to fall below this level when the storage-land ratio is less than 5.0 cubic meters per square meter, thereby satisfying only a few participants on the scheme.

On very small projects the share of water "consumed" by evaporation is greater because the reservoir is shallower. This means that the relationship will probably need to be adjusted upwards, reaching 6.0 or even 7.0 cubic meters per square meter before farmers can practice some dry-season cropping. This hypothesis remains to be tested through further research.

### *Land tenure and the legal framework*

IIMI's research also revealed an urgent need to clarify the legal position surrounding irrigation schemes.

The introduction of irrigation drastically altered the traditional relationship between farmers and their land. The property rights traditionally administered by the village *chef de terres* were overturned. The state appropriated the land and reallocated it to farmers, while retaining exclusive property rights. Farmers settled on the scheme were expected to become members of a cooperative, thereby playing their part in the system's management.

The cooperative has experienced difficulty in holding its own against the traditional rural power structure. Often, it has been taken over, albeit indirectly, by the traditional leaders. For example, the privileged farmers of Mogtédo wield considerable influence over the running of the cooperative and the distribution of water. On the Dakiri Scheme, people closely connected to the traditional authority play a similar role. At Itenga, an influential local personality dominates irrigation activities and land tenure arrangements.

Over the past 20 years, legislation on irrigation has been subject to frequent changes. Some legal texts have been adopted but not implemented. Others remain as unfinished yet widely circulated drafts. Texts are inadequately disseminated and, frequently, not available in local languages. As a result there is often little awareness of the provisions of the law, even amongst those directly affected by them.

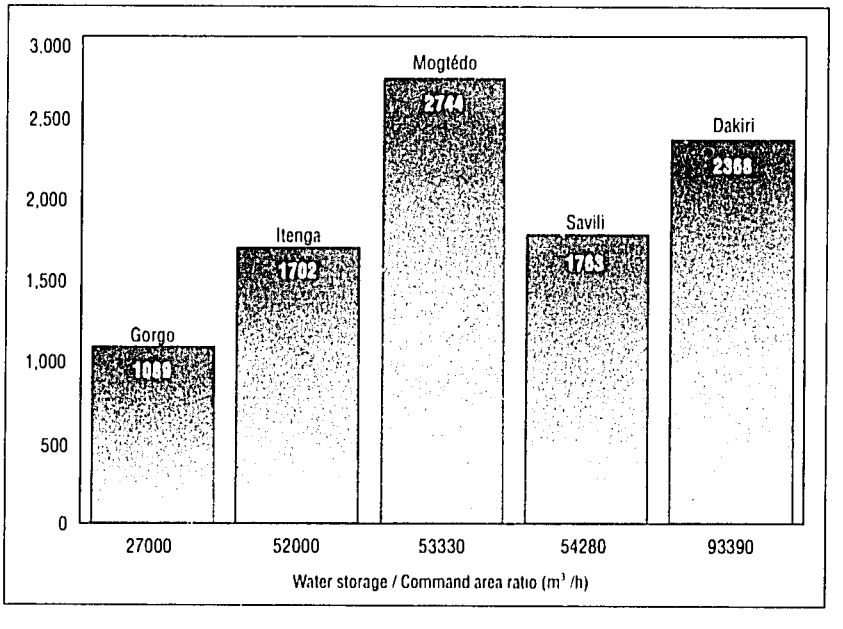
Under a land reform law passed in 1991, membership of a cooperative is no longer a prerequisite to benefit from irrigated land, which may now be allocated directly to individuals and the private sector. This law, with its wide-ranging implications, has not yet been implemented. IIMI has drawn the attention of the government to the urgent need to do so if its policy of irrigation management turnover is to prove successful.

## Conjunctive Use of Groundwater and Surface Water in Bihar, India

An important component of irrigation that is often under farmer management is the privately owned tubewells, used to tap groundwater supplies. Often, these wells lie within the command area of surface irrigation systems managed by government agencies. Such is the case in Bihar, India, where IIMI has carried out studies on the conjunctive use of surface water and groundwater to determine how this affects overall system management and performance. Field research was conducted in the command area of the Vaishali Branch Canal, which forms part of the Eastern Gandak command area in the north of the state.

It is often asserted that groundwater irrigation plays an important role in alleviating poverty in India. However, IIMI's findings, in one of India's poorest states, indicate that various constraints are hampering groundwater development, limiting its contribution in this respect.

*Figure 11. Water availability and net annual returns to land.*




Groundwater development by farmers is often seen as a response to the failure of large canal systems to deliver water equitably and efficiently. In this respect, Bihar appears typical. According to its design, the Vaishali Branch Canal is supposed to irrigate 63,289 ha. Construction was stopped before completion, and agency estimates show a command area of 17,200 ha. Official records show that during the dry season of 1992 the area irrigated was only 10,000 ha. Even within this area, reliability and equity problems abound.

Table 13 compares agency estimates of the area irrigated within the study area with the extents determined by the IIMI survey. The results show that agency estimates, compiled following an annual walk-through in which only sample fields are visited, are wildly exaggerated.

*Women have an increasingly important role in irrigated agriculture in Nepal.*

Within the Water Resources Department, canal water distribution is administered by one agency while another deals with groundwater and yet another with river lift irrigation. If a field is irrigated from the canal even once during the season, the agency concerned counts it as a canal-irrigated area. If groundwater is used, the groundwater agency also shows it as an area irrigated by groundwater. Thus there is no effective system for determining the true extent of either type of irrigation. While all agencies under the department have the common aim of helping farmers to irrigate their fields, in practice farmers must decide for themselves what kind of water to use at what moment, receiving little in the way of advice and support from any of the agencies concerned.

The tubewells used by farmers are of four kinds: private tubewells owned by individuals, group tubewells owned and operated by a group of contiguous landholders, group tubewells operated by a group affiliated with a nongovernment organization, and tubewells owned and operated by the state.

***Table 13. Official and study data on area irrigated in three sample minor commands of the Valshali Branch Canal (dry season, 1992).***

| Minor | Originally designed | Department records | | IIMI field observations |
|---|---|---|---|---|
| | | Target | Achieved | |
| Chakwa | 257 | 80 | 40 | 13 |
| Madanchpra | 249 | 39 | 35 | 25 |
| Shampur | 399 | 199 | 30 | 06 |

Frequent power cuts preclude the use of electric motors to drive the pumps, most of which are second-hand and diesel-operated. Engine efficiency is low, with 23 out of 26 engines tested having efficiency rates of under 36 percent while the remaining three operated at 47 percent. To blame are a variety of factors, including poor positioning of the pump in relation to the tubewell, the lack of trained mechanics, poor maintenance skills of farmers and the marketing of fake spare parts. Many farmers wrongly believe that placing the pump on a slope makes it more efficient. In fact, this is likely to increase maintenance costs significantly, without bringing any gain in efficiency.

By buying second-hand equipment, owners save on capital costs but incur high operation and maintenance costs. They seek to cover these costs by raising the price of water, particularly during periods of scarcity. In the poor wet season of 1992 most farmers without wells chose to lose their crops rather than pay for groundwater. As a result of these tactics, the volume of sales in local water markets is low, but profit margins are high. These trading conditions disadvantage the small-scale, resource-poor farmer, whereas for tubewell owners irrigation comes virtually free of charge.

Group ownership of tubewells allows poorer farmers to participate in tubewell development.

Encouragingly, the IIMI survey results show that group-owned tubewells operate more hours per year than privately owned ones. Their machinery is more efficient, their water costs are lower, and they irrigate a larger area. Where group ownership is supported by nongovernment organizations, farmers are assisted in buying inputs, using new crop varieties and diversifying out of rice. All this increases yields and hence incomes.

Despite these advantages, group ownership is catching on only slowly. Many of the poorest farmers are sharecroppers or laborers with no long-term stake in the land resource and hence no motive for investing in a tubewell. In addition, caste conflicts prevent cooperation, often between neighbors. And the state has done little to promote group ownership through subsidies or credit, preferring instead to install its own tubewells and lift irrigation schemes. Dependent on inadequate electricity supplies for their power, these systems too operate at low levels of efficiency.

A policy overhaul, switching government resources to the support of group tubewell ownership, may therefore be the best starting point in attempts to improve the lot of resource-poor producers in Bihar.

## Gender Issues

Despite increased attention to gender issues in other fields of agricultural research and development, the irrigation sector retains an unenviable reputation for ignoring them. It was to offset this imbalance that IIMI decided to conduct research on this topic, which cuts across all its programs but has its intellectual home under the local management theme. Research began in 1991, when the Institute hired a consultant. An associate expert joined the staff in 1992.

In 1993, a study was launched on the Chhattis Mauja System in the Terai of Nepal. This system was chosen because considerable background information on it was already available as a result of earlier studies by IIMI and others (see IIMI's 1992 Annual Report). Initial results show that, contrary to what is often assumed, the absence of males need not necessarily increase the burden of labor borne by women (see Box ).

### ROLE OF WOMEN IN THE CHHATTIS MAUJA SYSTEM OF NEPAL

The profitability of irrigated agriculture in the Chhattis Mauja System has declined in recent years, forcing many households to diversify their activities. Since male labor is both more expensive and more mobile, wives remain responsible for most farming and irrigation activities, while their husbands work in nearby cities or abroad. India and the Middle East are the main destinations of those emigrating in search of work.

Women whose husbands work abroad tend to be better off than those in families whose male heads have stayed closer to home. Their husbands' remittances make it possible to hire labor. Some women in this category leave all labor on the farm to hired hands, while they concentrate on small businesses off the farm. In contrast, households with males residing in the home often cannot afford hired labor, with the result that women perform most of the agricultural tasks.

Women are not allowed to provide the labor required to maintain the irrigation system. Yet if no labor is provided, households may pay a fine. In areas where there are many female-headed households, women have succeeded in getting these rules overturned.

In Sri Lanka, parallel studies are being conducted on three schemes, the Mahaweli H, Rajangana and Gampola Raja Ela schemes. They form part of a larger study on the participatory management policy and its implementation in Sri Lanka. In Rajangana and Mahaweli H, which are settlement schemes, the involvement of women in farming depends greatly on the crops grown, which in turn depends on water availability. Water shortages in Mahaweli H during 1993 made many

households turn to chili and vegetables—crops which require a great deal of female labor. At times like these women work long hours in the fields, yet they still have little or no say in how irrigation is managed. They do not participate in farmers' organizations unless the household has no male members.

In Niger, two case studies are under way in the Saga and Tillakaina systems, where IIMI's Niger program is already working. The few women who own irrigated plots in these systems are mostly widows who have inherited them from their husbands. In Tillakaina women face considerable difficulty in obtaining sufficient water at the right time. Although they are members of the cooperatives managing the systems they never attend meetings. Their feeling is that the cooperative will not do anything to help them.

Women who do not own irrigated plots are wives of men who do. These women seem to have very little to do with irrigation, being involved only in harvesting. The reasons for this appear to be both social—it is not seemly for women to "go in the mud"—and economic—irrigated agriculture is not profitable enough to justify their involvement.

In Saga, a women's group has been allocated a small plot for vegetable cultivation. However, this plot is not considered when water allocations are decided. First, the plot becomes waterlogged while the men's rice crop is still growing, since they drain their fields on to the women's plot. Then the women's plot dries out, because issues are stopped once the men's crops are ready for harvesting. Severe losses may result from these wild and wholly unnecessary fluctuations in water supplies.

Local management of irrigation ought, in theory, to provide a solid basis for the empowerment of women as equal partners with men in the irrigation process. IIMI's results so far give little grounds for believing that this is actually so in practice.

# COUNTRY PROGRAMS

IIMI has identified four regions of the developing world as constituting its geographical mandate area. They are South and Southeast Asia, West Asia and Northeast Africa, Northwest and West Africa, and Latin America and the Caribbean.

IIMI concentrated its initial work in South and Southeast Asia, because of the significance of irrigated agriculture in this region. In recent years, the Institute has extended its program to other regions. Research in each country is conducted through specific projects in collaboration with national partners, usually government agencies but occasionally nongovernment organizations. It is at the national level that the impact of IIMI's work is directly felt by its clients and stakeholders. These consist of national research managers, planners and policymakers, as well as farmers and consumers.

In 1993, IIMI pursued vigorous programs in nine countries. Its largest programs remain those in Sri Lanka and Pakistan. New operations are underway in Mexico, and it is hoped to report on initial work in this country next year. Resident programs in the Philippines and Morocco were scaled down during the year as projects in these countries came to an end.

Presented in this section is a general description of the context of IIMI's work in each country, the program and its components, and major activities during the year. More detailed accounts of the most significant findings have already been given in the thematic section of this report.

# South and Southeast Asia

Climates in this region generally display at least one season of generous rain, which supports large areas of rain-fed as well as irrigated agriculture. Although rain-fed production is strong, dependence on irrigation for the staple food crop is significant, as the population is well over the level that could be supported by rain-fed agriculture alone. Rice is the dominant irrigated crop, but there is increasing interest in diversifying into other crops, notably vegetables.

During the 1970s and early 1980s, the region achieved notable successes in increasing its rice production more rapidly than its population. However, in recent years, growing concern has been expressed regarding the sustainability of irrigated agriculture, especially in the high-potential systems, where waterlogging and salinity problems are thought to be increasing. Yields of rice in several countries have stood still since 1985, or at least grown only very slowly. The Consultative Group on International Agricultural Research (CGIAR), of which IIMI is a member, has warned that, unless these problems can be overcome, a new food crisis may occur in the region in the late 1990s.

The countries in this region with a major irrigation sector are Bangladesh, Myanmar, India, Indonesia, Cambodia, Laos, Malaysia, Nepal, Sri Lanka, Thailand, the Philippines and Vietnam. IIMI currently has country operations in Bangladesh, India, Nepal and Sri Lanka. Of these, Sri Lanka, the home of IIMI's headquarters, has the Institute's largest program in the region.

# Sri Lanka

## THE CONTEXT

Since Independence in 1948, Sri Lanka's irrigated area has more than doubled to over 550,000 ha. About 65 percent of this area is under major irrigation schemes. This heavy investment in irrigation has enabled the country to reduce its rice imports from 60 percent of annual requirements in 1948 to about 10–15 percent today. This has been achieved despite annual population growth of about two percent between 1948 and 1993.

Irrigated agriculture will continue to be the primary source of food and rural employment in Sri Lanka for the foreseeable future. Sustaining a high level of productivity in this important sector is crucial for the country's economic development.

With the completion of the Mahaweli River Diversion Project, the phase of expansion in the country's irrigated area has probably come to an end. The emphasis now is on increasing the efficiency of existing systems rather than on constructing new ones. There is an urgent need to rehabilitate existing systems and to improve their management. Crop diversification, while maintaining rice production at desired levels, is also needed. Both technological innovations and institutional reforms have a major part to play in this process. The task of IIMI's Sri Lanka Program is to assist the Government of Sri Lanka in achieving these goals.

*Irrigated agriculture will continue to be the primary source of food and rural employment in Sri Lanka, for the foreseeable future.*

## THE PROGRAM

IIMI's program in Sri Lanka consists of several interrelated projects and support activities, combining policy research with field studies. The program works primarily with government agencies, but also with nongovernment organizations and the private sector.

In 1990, the program began activities in support of the development of a comprehensive national policy for irrigation management. Known as IMPSA—the Irrigation Management Policy Support Activity—this initiative was implemented by a Secretariat of Sri Lankan professionals guided by a high-level Irrigation Management Policy Advisory Committee (IMPAC). The IIMI program provided technical inputs and office support services. This activity was concluded in 1992 and discussed in detail in IIMI's Annual Report for that year.

Under a major project now in its second phase, the program is applying participatory approaches to strengthening the management of two major irrigation systems, the Kirindi Oya and Uda Walawe systems. Agency officials and farmers conduct activities, and the processes and outcomes are monitored and documented by IIMI researchers. Four broad areas are covered:

- main system management; tertiary system management; pilot studies for crop diversification; and strengthening institutions.

A project to monitor and evaluate the government's new participatory management policy is funded through a technical assistance grant from the Asian Development Bank (ADB). This project, which began in September 1992, focuses mainly on the Integrated Management of Major Irrigation Schemes (INMAS), the Management of Irrigation Schemes (MANIS) and Mahaweli programs.

The Government of Sri Lanka has established an Irrigation Research Management Unit (IRMU) within the Irrigation Department, which has hitherto lacked a formal research arm. The unit identifies research needs, conducts or contracts research, evaluates results and promotes their implementation. It also monitors the planning and implementation of projects of the Irrigation Department, particularly the National Irrigation Rehabilita-

tion Project (NIRP). IIMI has assisted in establishing the unit and building its capacity.

The Irrigation Department and the Asian Development Bank (ADB) have asked IIMI to undertake a cost-benefit and impact assessment study on the Kirindi Oya Irrigation Settlement Project (KOISP). This project has had a chequered history. After initial construction, it had to be scaled down following cost overruns and the discovery that water supplies would be less plentiful than originally calculated. Project design and components changed frequently during construction.

IIMI's study began in October 1993 and will be completed in October 1994. Besides determining the costs and benefits of the scheme, the study will also try to identify the lessons learned. These will be used in the planning and implementation of future projects.

Under a collaborative project with the Tropical Agricultural Research Center (TARC) of Japan, IIMI is studying the potential for improving tank cascade irrigation systems. This study is being conducted in the Thirappane area, about 30 km south of Anuradhapura in north central Sri Lanka. This cascade area contains six interconnected tanks on either side of a small watercourse which ends in the Nachchaduwa Reservoir.

Finally, the program is also taking part in a novel project on the shared management of natural resources. This project is based on the premise that increasing users' control is vital to securing the more productive, equitable and sustainable use of land and water. A unique feature is the focus on whole watersheds, emphasizing the need to integrate development in different parts of the watershed—upper catchment areas, reservoirs, command areas, and downstream areas. Two pilot watersheds namely, Huruluwewa in the dry zone and Upper Nilwala in the wet zone, are included in the project. Funded by USAID, this project is being undertaken in collaboration with the relevant government agencies.

## ACTIVITIES IN 1993

The program helped prepare a project proposal for the master planning of water resources in Sri Lanka. This is one of the initiatives recommended under IMPSA. The master plan is to have four key components: an inventory of water supplies, an analysis of present and future demand, a discussion on water conservation and utilization, and the identification of staff and training needs. IIMI is also providing technical inputs into the preliminary studies now under way.

The project on strengthening management at the Kirindi Oya and Uda Walawe schemes made considerable progress during the year. At Kirindi Oya a plan for cropping patterns and seasonal water allocations was formulated, discussed with farmers and agency officials and implemented. Steps were taken to improve main system performance by introducing a management information system. As a result of water balance studies and the development of a computer model, water releases from the system's main reservoir and drainage water flowing from new parts of the scheme to the old can now be calculated more accurately. Pilot studies were conducted on crop diversification and the use of supplementary irrigation, and a study on salinity diagnosed the causes and proposed some solutions.

At Uda Walawe, work on institutional strengthening, pre-season maintenance, and the planning of land preparation and crop production was extended to the whole of the Moraketiya Branch Canal, covering an area of about 7,000 ha. A strategy was developed for crop diversification along the Right Bank Main Canal. Work on main system management included the installation of flow gauges, the introduction of a seasonal water distribution plan, the preparation of schedules, flow monitoring and the introduction of improved data collection and processing. This work together with other improvements in system management saved an estimated 10 million cubic meters of water in the maha rainy season of 1992/93, compared with the amount used the previous year. A joint Water Management

Committee was established to extend the results to the whole scheme.

Monitoring and evaluation of the government's participatory irrigation management policy continued during the year. To plan the detailed data collection, a field reconnaissance of the schemes covered by the project was undertaken. The data from this study were used to select research sites and design further data collection efforts. The latter consist of recurrent surveys of 30 farmers' organizations in 18 schemes, process documentation for 6 farmers' organizations in 6 schemes, and a large-scale survey that will cover about 150 farmers' organizations in at least 50 schemes.

Analysis is being undertaken to determine the major factors affecting progress in forming farmers' organizations and joint management committees and to suggest ways in which the agencies concerned can make their efforts more effective.

Findings so far are that farmers' organizations in INMAS schemes function reasonably well, but with significant variations. Many farmers' organizations and joint management committees continue to need agency support, which they are unable to obtain because of staff shortages. Officially, many distributary channels have been turned over to farmers' organizations, but in fact most still get extensive support from the government.

Farmers' organizations in MANIS schemes are better developed than expected—70 percent of the systems visited had farmers' organizations of some sort, while 50 percent had project management committees. However, they appear to vary greatly in effectiveness.

Farmers' organizations exist throughout the Mahaweli schemes and are being strengthened. In 1993, joint management committees were also created in the Mahaweli schemes and have been learning their roles and functions. No turnover of management functions has yet occurred.

After preparatory activities in 1992, IRMU was established in 1993, with two IIMI research staff assigned to a field office at Galgamuwa, within the Sri Lanka Irrigation Training Institute (SLITI). A strategic plan and mid-term research agenda were drafted and circulated for comments, and a workshop was held on 28 October to discuss their contents. Forty participants from different organizations dealing with irrigated agriculture participated. A small research library has been established, and books, journals, technical reports and articles are being acquired. Steps have been taken to improve the library's physical facilities, including the procurement of computers.

The unit has already launched its own research program, with a strong emphasis on the needs of NIRP. A study on the potential for the conjunctive use of agro-wells and surface water began during the maha season of 1992/93. An evaluation of rice-chilli intercropping in water-deficit irrigation systems in the dry zone was undertaken as part of efforts to encourage crop diversification. This study has shown that rice and chilli can be intercropped successfully in this zone. In addition, sites were selected for research on micro-catchments, and a study monitoring farmers' involvement in NIRP's rehabilitation projects got under way.

During the year, on July 15 and 16 IRMU also organized a 2-day workshop at SLITI, Galgamuwa on computerized decision support models. On the recommendation of the workshop a pilot study comparing the performance of the most promising models will be conducted.

Preparatory work on estimating the costs and benefits of KOISP was carried out. The benefits covered will be analyzed from three main points of view: agriculture (production); the human population of the area, including women (equity); and the environment and natural resources (sustainability). A large-scale sample survey will cover a minimum of 500 households. This will be supplemented by special studies.

Preliminary findings of the study on tank cascade systems were given in IIMI's 1992 Annual Report. Two years' data on system hydrology are now available. Following data analysis, a working paper will be published on this subject. Among the socioeconomic issues currently under study are the changing roles of the government in relation to minor tank communities, as political and administrative devolutions continue. In the project area, the roles of the several government organizations present overlap, but none has adequate resources to deliver much practical assistance.

*In Sri Lanka, the project on strengthening management at the Kirindi Oya and Uda Walawe schemes made considerable progress in 1993.*

Implementation of the project on the shared control of natural resources began in September. A core group of senior government officials directly involved in natural resources management spearheaded the design process, which involved consultations with a wide cross-section of resource users, government officials and representatives of nongovernment organizations at field and provincial level. Two pilot watersheds for project implementation were chosen, Huruluwewa and Upper Nilwala, in the North Central and Southern provinces, respectively. Workshops were held for national policymakers, provincial-level officials, field-level officials and for user groups, both in Colombo and in the project areas.

The main themes identified for work in the Nilwala watershed include integrated water management, shared control of forests, the development of model homesteads, the promotion of organic farming, the introduction of improved processing and marketing, the improvement of tea/rice culture through land consolidation and the prevention of environmental hazards, and the identification and strengthening of local resource users' groups. Similar themes were selected for the Huruluwewa watershed, where the regeneration of tank ecosystems was an additional theme. The project will also conduct research on water balance and integrated water management, bio-diversity (including endemic resources and medicinal plants), indigenous knowledge and practices, ecotourism, vegetation change and rainfall, improving water utilization, social conflicts, the potential for agri-business and the economics of irrigation.

During 1993, the program organized two major technical workshops, one on decision support tools for operation and maintenance, and the other on macrocatchment management and performance evaluation. A third workshop, on IRMU's strategic plan and medium-term research program, was also organized. In addition, a series of workshops and training programs was held for agency officials and farmer representatives under the research project at Kirindi Oya and Walawe. And, as already noted, several workshops were held to launch the new project on sharing the control of natural resources.

The monthly seminar series launched by IRMU in 1992 has been well received. Twelve seminars have now been held, covering a wide range of topics.

Participants from the Irrigation Department, IRMU, the Agrarian Research and Training Insti-

tute (ARTI) and the provincial councils took part in a group training exercise on the rapid appraisal of irrigation systems for rehabilitation and modernization. Individual training included the hosting of two graduates from Silsoe College, U.K. on post-graduate internships. These students were from Ghana and the Netherlands. An IIMI research officer completed a masters degree in agricultural economics. The program is hosting three Sri Lankan research fellows who are pursuing M.Sc. and M.Phil. degrees at Moratuwa University and the University of Peradeniya. In addition, IIMI staff supervised theses research at Post-Graduate Institute of Agriculture and at Ruhuna University.

Major publications during the year included a paper entitled "Cumulative Relative Water Supply: A Methodology for Assessing Irrigation System Performance," which was published in *Irrigation and Drainage Systems* 7: pp. 43–67. Several papers were presented to workshops, both in Sri Lanka and overseas.

# Bangladesh

## THE CONTEXT

Bangladesh lies on the combined delta of the Ganges, Brahmaputra and Megna rivers. The density and poverty of its predominantly rural population—currently more than 1,000 people per square kilometer of arable land and growing at more than 2.4 percent per year—exert enormous pressures on the country's natural resources.

Virtually all the 9 million hectares of cultivable land in Bangladesh are already in use. Efforts to increase agricultural production must therefore focus on increasing yields and/or cropping intensity. Each of these approaches requires more and better managed irrigation. Currently, about a third of the country's cultivable area is irrigated to some extent. Some 80 percent of this is served by motor-driven shallow tubewells, deep tubewells and low-lift pumps. Major canals serve only 7 percent of the irrigated area. The remaining 13 percent is irrigated using traditional manual techniques. It is believed that the country's use of irrigation could be more than doubled, particularly through the increased use of groundwater.

IIMI's country program in Bangladesh faces a somewhat different environment to that encountered elsewhere. With irrigation relying so heavily on small-scale technologies, the management of most individual systems (of which there are hundreds of thousands) is of necessity noncentralized. Each pump system is, formally or informally, autonomous. As a result, there can be no single national agency with both the mandate and the means to manage the minor (non-canal) irrigation sector. The prevalence of small-scale technology allows considerable scope for privatization, which has recently been given a good deal of impetus by the market, the government and donors. Privatization is leading to increased local control, of both water deliveries and water sources. It is also leading to pressure on government agencies to redefine their roles and to develop ways of facilitating turnover.

## THE PROGRAM

IIMI's program in Bangladesh focuses on the management issues associated with the utilization and expansion of irrigation systems in an increasingly privatized environment, particularly in the minor irrigation sector. This focus affords opportunities to work with government agencies such as the Bangladesh Water Development Board (BWDB)

and the Bangladesh Agricultural Development Corporation (BADC) as they seek to change their roles and to facilitate privatization and participatory management. The program also interacts with nongovernment organizations, which often cater to the needs of groups traditionally outside the rural power structure, such as landless laborers and women. Lastly, it helps to identify opportunities and problems in the market's provision of irrigation services. This inter-institutional approach, spanning the different sectors involved in irrigation, fills an important gap in Bangladesh.

IIMI has been working in Bangladesh since 1988. A consultative committee (with representatives drawn from various ministries, agencies and research institutions) works with the Institute's program in setting guidelines for program development and reviewing past activities.

Before 1993, IIMI's field research in Bangladesh was dominated by a collaborative project with the International Rice Research Institute (IRRI) and the Bangladesh Rice Research Institute (BRRI). This project had field components at three locations: (a) the Ganges-Kobadak Irrigation System, a major lift canal system operated by the Bangladesh Water Development Board (BWDB); (b) the North Bangladesh Tubewell Project (NBTP), also operated by BWDB but using deep tubewells located near Thakurgaon; and (c) tubewells under various forms of management—private, rental and public—in the Rajshahi Region. Some of this research was comparative in nature, especially with regard to the different types of tubewells used, while some would be better described as action research, specifically a very successful canal rotation experiment emphasizing user-agency interaction in the Ganges-Kobadak System.

Other pre-1993 activities included inputs into a joint project between BWDB and the Bangladesh University of Engineering and Technology (BUET) on irrigation management, and a series of workshops to assess training needs, conducted with BADC. These workshops provided an opportunity for BADC's top managers to explore the implications of their organization's changing roles as the minor irrigation sector becomes increasingly privatized. In addition, a regional workshop on farmer-managed groundwater irrigation systems was held in Dhaka.

## ACTIVITIES IN 1993

In June 1993, an agreement was signed between the Asian Development Bank, the Government of Bangladesh and IIMI for a collaborative 2-year study with the Ministry of Agriculture on privatization of the minor irrigation sector. The study's objectives are to review the current status and impact of privatization at the district and pump levels and to identify future opportunities and constraints. A study advisory committee was established and a field research team, from the Bureau of Socio-Economic Research and Training (BSERT) of Bangladesh Agricultural University, was selected.

The team worked on refining the design of the study, developing questionnaires and other research tools and preparing for the deployment of field researchers to five districts around the country. To reveal conditions that facilitate or constrain minor irrigation development, the study districts were chosen so as to represent areas which are either relatively advanced or underdeveloped in this respect.

During the year program staff worked with BUET researchers on the design of a pilot program to improve the management of surface irrigation schemes. This was a follow-up to previous efforts in this area. Central to the pilot program are interventions to increase the involvement of farmers in tertiary-level operation and maintenance. The implementation and effects of these management changes will be studied during the spring and monsoon rice seasons of 1994.

In February, the research network on Irrigation Management for Crop Diversification and the IIMI-Bangladesh program organized a workshop in

Dhaka on the theme of Ensuring Reliable Water Supplies for Crop Diversification. Representatives from nine countries attended. The papers presented identified the similarities and differences in experiences and strategies between countries. The 34 participants went on field trips to the Comilla, Tangail and Mymensingh areas, which illustrated some of the crop diversification issues prevalent in Bangladesh.

The program contributed to training events organized by BARC and BRRI on irrigation management for crop diversification in rice-based systems. In addition, follow-up work on the human resource development activities of previous years was done in association with IIMI's training unit. One outcome of these activities is a paper on institutional change at BADC, which will be produced shortly.

IIMI's memorandum of agreement with the Bangladesh Government was renewed in 1993. The future of the program was the subject of intensive discussion with government officials, donors, and senior IIMI management.

# India

## THE CONTEXT

India's irrigation sector is one of the world's largest public-sector investments. An estimated 76 million hectares or 46 percent of the country's arable land now receives irrigation of some kind. The technology used ranges from dugwells through deep tubewells to innumerable tank and river diversion systems.

The sector is performing far below potential. In many large-scale systems, productivity is stagnating or declining, leading to fears of a new food crisis at the turn of the century. A recent World Bank review points to poor planning and financial management and to inadequate operation and maintenance as the main causes of this mediocre performance.

## THE PROGRAM

IIMI's program in India began in 1989. The Institute has no resident scientist in the country, but provides assistance and support through exchange visits between its professional staff based in Colombo and some 40 collaborating Indian professionals. The latter have conducted a considerable amount of field research to understand management approaches and performance in irrigation systems in four states—Tamil Nadu, Gujarat, Uttar Pradesh and Bihar.

In Tamil Nadu, staff from Anna University, the Irrigation Management and Training Institute, and the Public Works Department have analyzed the performance and main system management processes of the Tamiravaruni Irrigation System. In Gujarat, similar studies have been conducted in the Mahi-Kadana Project by professionals from the Water and Land Management Institute, the Institute for Rural Management and the Irrigation Department. Research in Uttar Pradesh has concentrated on the conjunctive management of groundwater and surface water in the Madhya Ganga Project, which is still under development. This research has been conducted by scientists from the University of Roorkee, the Uttar Pradesh Water and Land Management Institute and the Irrigation Department. Finally, research in Bihar has focused on conjunctive use in another unfinished project, the Eastern Gandak Project. IIMI's partners here have been the Bihar College of Engineering, the Bihar Water and Land Management Institute and the Irrigation Department.

IIMI's role has been that of catalyst, bringing the various parties together in joint research projects and assisting in framing research questions and developing research methodologies. The Institute

*In India, a 3-year study on irrigation management turnover began in 1993.*

has also provided strategic inputs where necessary, linking the researchers to the larger international research environment.

A further study on the Mahi-Kadana System began in April 1993. This will study the impact on performance of the new data collection system successfully introduced to the scheme under the previous project. The collaborating partners are the Water and Land Management Institute and the Water Resources Department of the Gujarat State.

A 3-year study on irrigation management turnover in India began in October 1993. This study will determine the kinds of turnover occurring, develop a detailed understanding of the processes and constraints involved, and evaluate the impact of turnover, including its equity effects. Phase I will consist of a reconnaissance of policies, programs and events, and will be carried out in six states. Phase II will be a more detailed study, carried out in two states only. This study is being conducted in collaboration with the Indian Institute of Management, at Ahmedabad.

## ACTIVITIES IN 1993

The four initial collaborative research projects in Tamil Nadu, Gujarat, Uttar Pradesh and Bihar states were completed in March and submitted their final reports shortly thereafter. The recommendations were presented through workshops to state irrigation professionals and policymakers. The reports are now being revised and synthesized so as to bring out an IIMI-India country paper highlighting the research findings.

Most of the projects' findings were described in IIMI's 1992 Annual Report. In the Madhya Ganga Project, further research was conducted on a model to determine the optimal allocation of surface water and groundwater for different cropping patterns. This showed that if 15 percent of the area currently cultivated to maize were to be used for rice instead, the level of the water table, which is currently declining, would stabilize, with no changes necessary in canal operations. To improve the conjunctive management of groundwater and surface water, the project has proposed a matrix organizational structure involving farmers and agency staff from groundwater and surface water organizations.

The study on the conjunctive use of groundwater and surface water in the Eastern Gandak System of Bihar showed that government statistics on the areas irrigated by both surface water and groundwater are incorrect. In the sample areas, far less land is irrigated with surface water than is supposed. However, groundwater development is constrained by the high cost of diesel, poor maintenance and low efficiency. There is a strong local market in groundwater. The institutional environment created by the government fails to support either surface water or groundwater usage effectively. (For a further discussion of these results, see page 47).

The data collection procedure successfully introduced and tested by the Gujurat team in pilot

areas of the Mahi-Kadana System has now been extended and adopted throughout the project area. It serves as the basis for introducing a management information system that will be used to test various performance indicators. The data collected are currently being entered on computers and processed. The results obtained so far were discussed in a workshop held in December. The project will continue until May 1994.

The study on turnover was launched in October. A literature review was completed by the year's end.

Five members of the Indian National Commission on Irrigation and Drainage (INCID) visited IIMI headquarters in February to understand its global role and activities, interact with its scientists and discuss the Institute's future program in India. They visited some Sri Lankan irrigation systems in which participatory management is being implemented.

A workshop on the future of collaborative research in Tamil Nadu was held in Madras on 29 March. The objectives were to obtain the views of irrigation professionals, managers and policymakers on the desirability of further collaboration, and to identify the priority areas and issues that could be addressed. About 30 participants attended. One outcome was the formation of a consultative group on irrigation management research. This group will coordinate future research and encourage networking.

A paper on IIMI's potential contribution to irrigation management research nationwide was prepared by an external consultant. This will provide the basis for further discussion with Indian political leaders on the establishment of a long-term program in the country.

# Nepal

## THE CONTEXT

Nepal is experiencing unprecedented changes in its political and economic climate in general, and in its irrigation sector in particular. Both are undergoing increasing democratization and privatization.

The country's eighth Five-Year Plan (1992–97), produced by the National Planning Commission in November 1991, states that nearly half of Nepal's population or an estimated 8 to 9 million people now live below the poverty line and are deprived of basic human needs. At the heart of the problem is the fact that population growth has outpaced the increase in food supply. Increasing food production is therefore one of the plan's key elements. The country's irrigation sector is expected to provide a significant share of this increase.

Nepal's diverse terrain makes it difficult to have a single-faceted policy towards irrigation development. The potential for expanding the irrigated area lies mostly in the terai (plains), but there is also some potential for further development in the hills. The Eighth Plan emphasizes that, in both new construction and rehabilitation, efforts should be directed towards medium- to small-scale irrigation systems.

The major national institutions involved in the irrigation sector are the Department of Irrigation (DOI), which undertakes infrastructure development for medium- to large-scale systems, and the Agricultural Development Bank of Nepal (ADBN) which, together with various other institutions, including international donors as well as national agencies and nongovernment organizations, supports small-scale irrigation development.

Over 60 percent of Nepal's irrigated area is now managed by farmers. In the past 5 years, both government and nongovernment agencies have provided strong support to farmer management and to the process of management transfer. The government is committed to increasing farmer participation still further, and to the complete transfer of management wherever possible. The objective of IIMI's program in Nepal is to help the government achieve these aims, which require considerable strengthening of farmers' organizational capacities as well as the reorientation of existing government agencies.

## THE PROGRAM

IIMI established its program in Nepal by posting a resident scientist to the country in 1985, at the request of the Water and Energy Commission Secretariat (WECS). The program's initial objective was to advise the government on how best to assist existing farmer-managed irrigation systems. Funding was provided by the Ford Foundation and the International Fund for Agricultural Development (IFAD).

Between 1985 and 1989, IIMI collaborated with WECS in planning and implementing an extensive field research project in the hills. The project showed that, although a high degree of supervision was necessary to mobilize farmer participation at the outset, this resulted in stronger water users' organizations and in farmers' increased ability to mobilize their own resources, leading eventually to a reduction in operation and maintenance costs. Most important was the fact that farmer involvement in system rehabilitation led to more efficient operations and better subsequent maintenance.

The lessons of the WECS project had important implications for the DOI, which subsequently requested IIMI to support and strengthen its own initiative to improve irrigation management. IIMI and the DOI identified several problem areas in which IIMI could contribute, and a memorandum of agreement between the two institutions was signed in 1989.

A research project on increasing farmer participation in the management of the Banganga Irrigation System began later that year and was completed in 1992. The results are given in IIMI's 1992 Annual Report. Several other irrigation systems at various stages of the management turnover process are now under research by IIMI. They include systems at Rajapur, where a rehabilitation project funded by the Asian Development Bank (ADB) is under way.

*In Nepal, IIMI continued to provide assistance to the development of water users' associations.*

In 1990, IIMI began collaborating with the ADBN to document and evaluate various irrigation projects financed by the bank. This activity was funded by the Ford Foundation. The study showed that loan repayment was higher in projects where farmers were effectively organized than in those where they were not. It also identified a lack of technical support for the ADBN staff

responsible for planning, designing and implementing irrigation projects.

In 1992, IIMI began assisting in the development of a database on Nepal's irrigation institutions and systems. Funded by the Ford Foundation, this work was conducted in collaboration with the Workshop on Political Theory and Policy of the Indiana University, USA and the Institute of Agriculture and Animal Sciences (IAAS) of the Tribhuvan University, Nepal. Once completed, the database will be made available to practitioners, researchers and policymakers. In 1994, it will be transferred to an appropriate Nepali institution, whose staff will be trained in its use.

In September 1992, a national workshop on the role of nongovernment organizations (NGOs) in irrigation development and management was organized jointly by IIMI and ADBN. A quarter of the papers were prepared and presented by farmers, most of whom were leading members of well-established water users' associations. This workshop, and subsequent follow-up activities, were funded by the International Labour Organisation. One outcome of the workshop was the creation of a national NGO irrigation network. In addition, IIMI's support has led to the formation of a confederation of water users' organizations from more than 10 districts in Nepal. Farmer-to-farmer training activities have also been strengthened.

## ACTIVITIES IN 1993

A major activity at the start of the year was a review of the IIMI program in Nepal. IIMI's Director of Research headed the review team, which met key staff in collaborating government agencies and the donor community. The outcome of the review was that the IIMI program should broaden its activities beyond those related to local management to encompass areas such as performance assessment, the environmental impact of irrigation, gender issues in irrigation, irrigation policy and the management of public-sector irrigation. Several of the year's subsequent activities may be seen as a transition towards this broader role for the program.

Under the memorandum of agreement with the DOI, IIMI studied farmer participation and institutional development processes in the Rajapur Rehabilitation Project. Rajapur is not a single system but rather a complex network of systems, with a large total command area of 13,000 ha, much of which is already farmer-managed. The six existing water users' organizations have merged to form a single confederated association to negotiate with the DOI on key rehabilitation issues and take over responsibility for managing the network as a whole. This is the first project in which the DOI and the ADB have agreed to allow farmers' associations to participate in the planning, design, construction and operation of the rehabilitated systems. A project management committee, consisting of the project manager (from the DOI) and all the members of the central farmers' committee, has been formed and has met several times. IIMI acts as process documentor and is an official observer both at these meetings and at those of the six water users' organizations. An interim report regarding this activity has been submitted to the DOI.

The year saw the start of the much delayed "district strengthening" activity. The aim of this activity is to improve the quality of the support provided by DOI district staff to farmer-managed irrigation systems. Staff are trained to make an inventory of irrigation systems for use in prioritizing irrigation development projects for rehabilitation and other services. The inventory serves as an input into a geographic information system. This activity is funded by the Ford Foundation, the Bundesministerium für Wirtshaftliche Zusammenarbeit (BMZ) and the International Fund for Agricultural Development (IFAD).

Applying the inventory approach in a single watershed within a small hill district, the Institute of Agriculture and Animal Sciences (IAAS) found more than 200 farmer-managed irrigation systems. Clearly, if assistance is to be provided on a broad

scale, an inventory will be essential, both for identifying those systems deserving priority and for monitoring the allocation and use of resources. For two other districts, one in the hills and the other in the plains, the first stage of the approach, consisting of a reconnaissance survey, has now been completed.

During the year a consultancy group from the National Irrigation Administration (NIA) of the Philippines provided training to DOI staff in farmer participation in irrigation development activities. The training proved highly effective in imbuing participants with a stronger client orientation.

As a follow-up to the evaluation project with ADBN, IIMI began activities to strengthen the expertise of staff in the bank's irrigation loan program. Staff were assisted in assessing participatory training needs, drafting terms of reference for evaluation studies, and preparing manuals.

Continuing its work to strengthen the role of NGOs, IIMI provided various kinds of assistance to the development of water users' groups, including the provision of training for group leaders, the establishment of a directory of water users' organizations and the launching of a newsletter for information exchange among NGOs involved in irrigation development and management. The training was organized by the Center for Rural Technology, itself a prominent NGO at national level. The newsletter and directory were also initiatives proposed by NGOs.

Work on the development of a database on irrigation systems and institutions continued, with the number of irrigation systems included rising to 173.

Other activities in 1993 included the implementation of studies on performance assessment and gender issues in a terai irrigation system. The preliminary results of the gender study are given on page 49. IIMI helped develop a course on irrigation management at the Institute of Engineering, where a seminar series was also launched. The National Planning Commission (NPC) invited IIMI to advise its technical support committee in drafting the Agricultural Perspective Plan. Also at the request of the NPC, IIMI drafted a project to facilitate planning and policy formulation through the establishment of a database on irrigated agriculture.

At the initiative of IIMI and in collaboration with NPC and DOI, a national consultative committee on irrigation management was convened. The committee's first task was to review and guide the future activities of IIMI in Nepal.

## West Asia and Northeast Africa

Average rainfall is low virtually throughout this region, many of whose countries rely almost entirely on irrigation for the production of food and fiber. The region is characterized by broad and fertile floodplains and valleys, created by major rivers rising in mountainous areas. Supplementary irrigation using groundwater is also widely used. Human populations crowd the better-watered areas, the carrying capacity of nonirrigated land often being very low. In many systems, almost all surface water resources have been captured, so that better management of water is the only way forward. The increasing use of pumped groundwater is lowering water tables. Competition for water between agriculture and the region's rapidly expanding major cities is a major issue.

The countries in this region with a major irrigation sector are Pakistan, Iran, Iraq, Syria, Egypt and Sudan. IIMI has so far concentrated its activities in Pakistan and Sudan. Initiatives are under way to extend these activities into Egypt.

# Pakistan

## THE CONTEXT

Pakistan's population, estimated at more than 110 million in 1990, is likely to reach 150 million by the year 2000. About 70 percent of its people live in rural areas and are primarily dependent on agriculture, which is the mainstay of the country's economy.

With a gross irrigated area exceeding 16 million hectares, Pakistan ranks fifth in the world and third among developing countries in the extent of its irrigated land. In the Indus Basin it has the world's largest contiguous irrigation system, comprising over 60,000 kilometers (km) of irrigation canals and more than 1.6 million km of watercourses and field channels. The irrigation infrastructure also includes 12,500 large public tubewells, more than 275,000 small private tubewells and some 16,000 km of surface drains.

Studies of the Indus Basin have suggested that it has one of the world's most favorable environments for large-scale, intensive irrigated agriculture. Pakistan is thought to be one of the few Asian countries with a potential to substantially increase the output of its irrigated sector and to export food in the 21st century. In stark contrast to this optimistic assessment are the shortfalls in future national food and fiber production needs—10 percent by 2000, 25 percent by 2013—predicted by the recently published Water Sector Investment Plan. The plan's pessimism is well founded: average yields of the country's major crops have stood still or declined in recent years, and are in most cases less than 50 percent of those obtained by other major producing countries. The future productivity of Pakistan's irrigated agriculture is, then, subject to uncertainty. At the heart of the controversy is the sustainability of irrigated agriculture as environmental problems, including salinity and waterlogging, continue to thwart further productivity gains.

*In Pakistan, tubewells have become the farmers' response to inadequate deliveries of good quality canal water.*

Good quality surface water is arguably the scarcest, most valuable agricultural resource in Pakistan. Returns to investment in innovations that will lead to its more productive, sustainable and equitable use are bound to be high. However, as the water sector plan recognizes, achieving Pakistan's ambitious targets depends critically on eliminating the policy and institutional constraints that continue to depress the performance of irrigated agriculture.

## THE PROGRAM

IIMI's program in Pakistan began in 1986, when a number of international staff members were posted to Lahore.

Research activities were supported initially by an institutional development grant from the United States Agency for International Development (USAID), and later through specific project funding from the Government of the Netherlands, the

International Fund for Agricultural Development (IFAD) and the Asian Development Bank (ADB). During this early period, IIMI also collaborated with the Agha Khan Foundation, which was conducting a rural support program in the north of the country.

In January 1989, a project was launched with the aim of minimizing waterlogging and salinity through improved irrigation management. Initial efforts went into collecting data on irrigation practices and the quality of pumped groundwater. During the second half of the project, management innovations were tested at the distributary and watercourse levels of selected canal commands. In addition, computer programs simulating trends in salt and water balances over time were tested, and farmers' methods for dealing with salt buildup were investigated.

In August 1990, the Government of Pakistan approved a 3-year research project to improve the productivity of water resources in the remodeled Lower Swat Canal and the newly constructed Chashma Right Bank Canal systems of the North-West Frontier Province. The project is exploring the potential for introducing crop-based irrigation operations to these largely supply-driven systems. Funding for this project was allocated by the ADB in January 1991.

In 1991, IIMI accepted responsibility for the final 2 years' technical assistance component of the USAID-supported Irrigation Systems Management Research Project, which had begun in July 1986. This project aimed to strengthen national capacity for research on irrigation management at both the federal and the provincial levels, to contribute to the more efficient use of land and water resources through relevant research, and to improve the effectiveness of existing irrigation infrastructure. Some 12 sub-projects were undertaken by various national agencies under this project. In inviting IIMI to participate, USAID accepted that the Institute would have its own research component in addition to conducting technical assistance activities.

This enabled IIMI to continue its research on the development of computerized management support technology, which it had begun under the institutional development grant. The technology was used to predict the impact of different operational and maintenance inputs on the objectives of equitable and reliable water distribution. This research had been identified by irrigation agency officials as being particularly valuable for the Irrigation Department (ID). Hence, it is now a major focus for the department's collaboration with IIMI.

## ACTIVITIES IN 1993

The project to mitigate the effects of salinization and waterlogging ended in December 1993. It revealed considerable inequity in the distribution of canal water within distributary commands, compensated in part by extensive use of groundwater by farmers. Tubewell water is generally of lower quality than surface water, potentially contributing to salinity buildup in farmers' fields. Research also showed that farmers mitigated the effects of salinity on crop production by using tubewell water to adjust the frequency and depth of irrigation according to need. These efforts by farmers need to be supported by the periodic provision of good quality groundwater to flush the salt out of their fields. A model simulating trends in salt buildup was also tested under this project, the final year results of which are reported on page 12.

Research on management interventions to improve canal system operations, conducted in collaboration with the Punjab Irrigation Department, was completed by the end of the year at most locations. The exception is the Chistian subdivision of the Fordwah-Eastern Sadiquia Canal System in southeastern Punjab, where research on the introduction of the Irrigation Management Information System (IMIS) continues, with modest support from the Institute's core budget. IMIS was installed in a pilot area, using a participatory approach that closely involved the Irrigation Department.

In July, IIMI began working with the Centre National du Machinisme Agricole, du Génie Rural, des Eaux et des Forêts (CEMAGREF) of France on a project to address issues relating to water markets. The initial results of this work are reported on page 33. Fieldwork was conducted mainly in the Fordwah-Eastern Sadiquia Command Area.

During the second half of the year, the analysis and interpretation of the program's research data were supported by a newly installed geographic information system (GIS). Requests from collaborating institutions for services in this area are now becoming increasingly frequent.

Research to improve the productivity of irrigation water in the North-West Frontier Province continued throughout 1993. In the Lower Swat Canal, the introduction of crop-based irrigation operations in the near future now seems unlikely, following the agency's decision to suspend the installation of gated outlets. IIMI has conducted considerable research on the circumstances surrounding this decision, and on its management implications. This research is described on page 35 of this report.

The main activities on the Chashma Right Bank Canal included the computer modeling of hydraulic conditions, an evaluation of water deliveries and conveyance losses, and a baseline study of cropping patterns and farming practices. A workshop was held in March to discuss the preliminary findings of this study with representatives from the collaborating agencies.

IIMI's role in providing technical assistance under the Irrigation Systems Management Research Project came to an end in June 1993. In April, a symposium was held in Lahore at which the results of this project were presented and discussed. A final report has been written and submitted to the donor, as well as being shared with all other interested parties.

# Sudan

## THE CONTEXT

Sudan is the largest country in Africa. Its population, estimated at nearly 25 million people in 1992, is growing at 2.8 percent per year, outstripping growth in the GDP. The agriculture sector is immensely important to the country's economy, accounting for 38 percent of the GDP and employing about 80 percent of the population. It is also a big export earner, being virtually the country's only source of foreign exchange.

The total area of the irrigated subsector is about 1.89 million hectares, or 27 percent of the country's total area under cultivation. The Gezira Scheme alone occupies 0.882 million hectares. Other major public-sector schemes are New Halfa (0.151 million hectares), Rahad (0.126 million hectares) and the Blue and White Nile schemes (0.269 million hectares). There are five sugar cane schemes, with a total command area of about 0.1 million hectares, and many smaller but still significant public-sector schemes.

The irrigated sector thus plays a major role within the agriculture sector. It is a relatively secure source of food, especially in times of drought. It is also a major source of cash crops for sale in urban markets and as exports. It produces all the country's wheat and sugarcane, almost all its cotton and horticultural crops, and a substantial proportion of its sorghum and food legumes.

Among all the countries of the developing world in which irrigation is currently undergoing privatization, Sudan is perhaps the one in which the process is occurring most rapidly. The radical changes taking place throughout its irrigated sector were described in IIMI's 1992 Annual Report.

*In Sudan, irrigated agriculture plays an important role in the economy of the country.*

## THE PROGRAM

IIMI's program in Sudan began in mid-1989, when the Institute recruited an international staff member to establish an office in Khartoum. In October of that year a national policy workshop was organized in Wad Medani to identify important issues for collaborative research.

A major project to assist Sudan's Gezira Board was launched in 1990 and completed in October 1992. Its principal objective was to promote improved water management. Advice in this area was based originally on the results of selected experiments conducted at the Board's pilot farm, but later the scope was extended to cover new experiments on the farm as well as in other areas of the scheme, so as to obtain results that would be more broadly applicable.

A study of irrigation management and performance in the Rahad Irrigation Scheme began early in 1991. The scheme is unusual in that water is allocated by one agency, the Rahad Agricultural Corporation, but delivered by another, the Ministry of Irrigation. The objective is to assist management agencies and farmers in developing management practices that will improve the efficiency and equity of water deliveries. Work began in 1991 with the monitoring of supplies at selected control points along Major 5, a sub-main canal.

A study on the privatization of pumping schemes on the White Nile has been initiated in collaboration with the Advisory Unit of Agricultural Corporations (AUAC) and the White Nile Agricultural Corporation (WNAC). The objectives of this study are to compare management under the existing parastatal agency (WNAC) with that under private companies and farmers. Six schemes have been selected for this purpose, two from each management mode. In a further study, funded by the International Fund for Agricultural Development (IFAD), IIMI will train farmers and help them form the necessary organizations to fulfill their management responsibilities.

IIMI is also providing technical assistance to the Kenana Sugar Company. Studies on long furrow irrigation problems are being conducted to improve irrigation performance at the field level.

## ACTIVITIES IN 1993

In 1993, the program developed a new strategy for future operations in Sudan. It will broaden its

activities beyond the current focus on management turnover, undertaking more research in areas such as performance assessment. It will also devote more efforts to strengthening the national capacity for research, management and policymaking in the irrigation sector.

The team investigating the performance of the Rahad Scheme presented the preliminary results of its research on the scheme's Major 5 canal. Although overall water releases are close to crop water requirements, deliveries fluctuated considerably among individual reaches. Additional flow monitoring exercises were organized for agency staff. Indicators for the performance assessment of the whole system were identified. A 3-year project has now been approved and a steering committee established to monitor implementation.

Under the study on the White Nile pumping schemes, data were collected on wheat production under different management modes during the 1992/93 cropping season. If resources allow, a larger set of schemes will be covered during the 1993/94 season, so as to obtain a broader view of the productivity and sustainability of these schemes.

Several workshops were organized during the year. These covered various topics, including the planning requirements for new irrigation projects, sustainable water supply and disposal, the problem of sedimentation, and the management of the agency-farmer interface in irrigation systems.

A national network on irrigation management was formed and six issues of its newsletter were issued over a period of 6 months.

Individual training activities included the provision of support to a number of Sudanese students engaged in M.Sc. research. Field tours were organized in Pakistan and Sri Lanka for the First Under-Secretary of the Ministry of Irrigation and the Under-Secretary for the Hydraulic Research Station.

The program submitted various reports for review, including a background paper on the White Nile schemes, a status report on the privatization of agriculture in Sudan, a report on the performance of the Gezira Scheme, an assessment of economic issues surrounding cotton and wheat production in Sudan, the evaluation of the Major 5 canal in the Rahad Scheme, a study of the Nile River system and water resource development in Sudan, and a comparative study of irrigated crop production. Several project proposals were written and submitted.

## Northwest and West Africa

This region contains two contrasting agricultural traditions. To the north of the Sahara lie the dryland farming systems of the Maghreb, where irrigation was practiced in ancient times. To the south, irrigation is a relatively recent introduction, with major development schemes being constructed in the post-independence years across the West African Sahel. In both cases the irrigated sector is coming under increasing pressure as populations rise, bringing about a rapid increase in the demand for food.

Nigeria, with the region's highest population, is the most significant irrigating country in West Africa. IIMI's current program for this subregion is managed from an office in Ouagadougou, Burkina Faso. Individual country projects are under way in Burkina Faso, Niger and Nigeria. Work in each country addresses issues related to a particular type of irrigation system. A networking approach is used to exchange experiences and disseminate results. In Northwest Africa, Morocco is the country with the most advanced irrigation technology and institutions. Here IIMI has had a resident program, which was temporarily suspended in 1993 owing to lack of funding.

# Burkina Faso

## THE CONTEXT

Burkina Faso is a landlocked Sahelian country of 274,000 square kilometers. Its population of about 9.3 million is growing at just under 3 percent a year. Rainfall is unreliable, especially in the drier northern areas, and the irrigated sector assumes considerable importance for food security. Unlike its neighbors, Mali and Niger, the country possesses no major river, depending instead on streams in the upper watersheds of the Volta, Comoé and Niger rivers.

The development of irrigated agriculture began in the 1960s around small storage reservoirs originally built to provide water for domestic use, livestock and home gardens. There are many such reservoirs in the country (nearly 1,100 according to a recent survey) but only a small number of them, around 70, are thought to support irrigation systems at present. The irrigated agriculture sector as a whole is now estimated to cover about 16,000 ha, a modest area compared to the 3 million hectares covered by rain-fed agriculture, and only a tenth of the total area that could be irrigated.

Irrigation schemes range from traditional valley-bottom systems with basic infrastructure and little or no means of water control to schemes with relatively sophisticated infrastructure ensuring total water control. The latter type includes some village schemes.

There is no formal irrigation bureaucracy in Burkina Faso. Responsibilities in the irrigated agriculture sector are divided among a number of institutions belonging to either of two ministries, the Ministère de l'Eau (M-EAU) and the Ministère de l'Agriculture et des Ressources Animales (MARA). M-EAU sets national water resources policy and constructs and rehabilitates irrigation schemes, usually through the parastatal Office National des Barrages et des Aménagements Hydro-agricoles (ONBAH). MARA supervises the use of irrigation facilities through its Centres Régionaux de Promotion Agropastorale (CRPAs). Additional support for the promotion of farmers' organizations is provided by the Service Provincial de l'Organisation et de la Formation Professionelle des Producteurs (SPOFPP).

Like many other countries, Burkina Faso has adopted a policy to transfer responsibility for the management of irrigation to farmers.

## THE PROGRAM

IIMI's program in Burkina Faso aims to strengthen the ability of national institutions to improve and sustain the performance of small-scale reservoir-based village schemes.

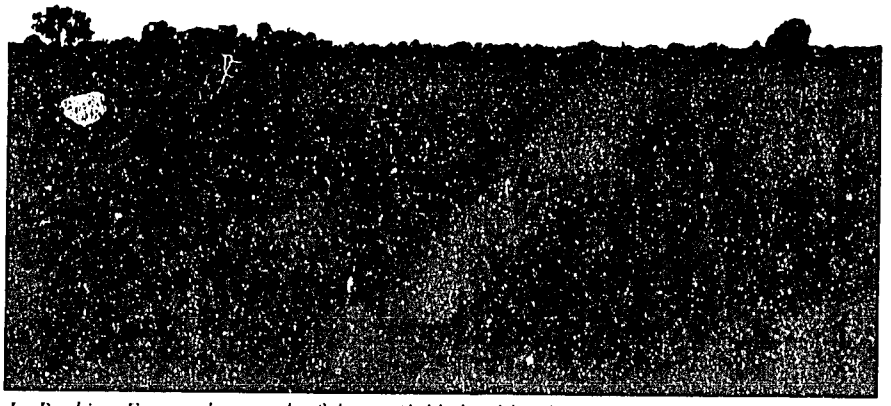
IIMI currently acts as the executing agency for a 4-year technical assistance project funded by the African Development Bank (AfDB) and executed under the auspices of M-EAU. The project began in April 1991. IIMI provides technical, operational and administrative support, reporting to a 9-member national coordinating committee made up of representatives of all the ministries and agencies involved in irrigated agriculture. Five representative village systems on the country's central plateau were selected for detailed study under the project, namely Mogtédo, Itenga, Savili, Dakiri and Gorgo.

The project has three principal components: research, professional development and information.

## ACTIVITIES IN 1993

Under the research component, diagnostic studies in the five village systems continued throughout the year. Activities included acquiring and updating

basic information on the physical infrastructure and organizational arrangements of each system, studying the supply and storage of water, assessing practices relating to water conveyance and distribution as well as to on-farm irrigation, and reviewing the institutional and legal context of irrigation development and management. The results of this work are reported in detail on page 29 and 44.



*In Burkina Faso, only a tenth of the available land has been irrigated.*

An annual progress report and a mid-term synthesis report were prepared and submitted to the donor, the coordinating committee and partner organizations. Several papers for national workshops were also prepared.

The year was a busy one for the project's professional development component. The program continued to support the research of one doctoral student and to provide on-the-job training to two young engineers. In addition, seven students at different stages of their university careers prepared theses or project reports based on field research carried out on IIMI's study schemes. The research topics included on-farm water management in the Mogtédo Irrigation Scheme, economic analysis of irrigated rice cultivation in Burkina Faso, the role of women in the Dakiri Irrigation Scheme, and the hydraulics of the Gorgo Irrigation System.

In collaboration with the regional technician training school, the Ecole Inter-Etats des Techniciens Supérieurs de l'Hydraulique et de l'Equipement Rural (ETSHER), the program organized two 2-week training courses for agency field staff, the first in January and the second in December. The courses aimed at improving the technical and management skills of the 20 agency staff who participated in each of them.

The program also sponsored the participation of two middle-level technicians in a 10-week training course on Water Management in the African Context, organized by ETSHER and the Centre National d'Etudes Agronomiques des Régions Chaudes (CNEARC) at Montpellier, France.

A 3-day national seminar on problems and prospects for irrigation development in Burkina Faso was organized in February. Nearly 100 participants attended. The principal topics discussed were: the challenges and constraints facing the sector; the definition of an appropriate technical, institutional and legal framework to support turnover and self-management; and the residual responsibilities of the state. Twelve papers were presented, a series of recommendations was formulated and the event culminated in a lively dinner-debate. The workshop proceedings were published shortly after the event.

A 1-week study tour of irrigation systems in Burkina Faso was organized in October for a group of 15 farmers and agency field staff.

Under the project's information component, 1,000 copies of the third issue of the bilingual (French-English) West African Irrigation Network Newsletter, devoted to irrigation in Nigeria, were produced. The fourth issue is in preparation.

Issues 1 and 2 of a national language newsletter on irrigation and the environment, *Namanegdzanga*, were produced in February and November, respectively. These 12-page and 16-page issues had a print run of 1,200 copies each and contained articles in two national languages—Mooré, the most widely spoken national language, and Gourmantché. Use of the latter language enabled the articles concerned to be read by farmers at the IIMI field site in the region of that name.

In 1993, the program's single project passed its halfway mark. The external mid-term review, commissioned by the donor, evaluated its achievements and suggested future directions. A response to the evaluation report is being formulated in collaboration with the Coordinating Committee. The program was also visited by IIMI's External Program and Management Review Panel in November.

Building on the knowledge gained through field research, the program has begun addressing policy issues. The most urgent of these concern security of land tenure, the sharing of responsibilities between the state and the farmer in the context of management turnover, and the creation of conditions conducive to the formation of effective and viable farmers' organizations. The February national workshop proved a particularly effective forum for conveying the importance of these issues to key players in the country's irrigation sector.

# Niger

## THE CONTEXT

Vast, landlocked and arid, Niger possesses limited potential for expanding rain-fed agriculture. With its population rising by 3.3 percent a year, the country must make improved use of its scarce water and land resources for irrigation if it is to reach its goal of food self-sufficiency. Current estimates place the irrigation potential of Niger at 270,000 ha, of which around 30 percent (81,000 ha) are being exploited at present. Irrigated production represents roughly 10 percent of the total agricultural output.

Recurrent droughts are only partially offset by the presence of several major sources of surface water. The most important of these is the Niger River, which flows for over 550 km through the southwest of the country. Most of the country's modern irrigation schemes, with total water control, are found along its banks.

The size of Niger's irrigated perimeters ranges considerably, from a few hectares to several thousand, with the average size along the Niger River estimated at 200 ha. There are currently more than 30 irrigation schemes of this kind, covering over 7,500 ha. Development of these schemes costs an average of US$24,000 per ha and rehabilitation approximately US$4,800 per ha. Between 1987 and 1990, nearly 40 percent of the schemes with full water control were rehabilitated, thanks to major funding from several donors. Most schemes practice double-cropping of rice, with average yields now reaching 5 tonnes per ha per season (i.e., 10 tonnes per year)—high by African standards.

Farmers are shouldering an increasing share of the burden of organizing and supporting irrigated production as the government and donors steadily reduce their involvement in irrigated agriculture. However, the support provided to farmer-managed irrigation could be greatly improved. Farmers have, until recently, been forced to form cooperatives, yet these have no legal status. Cooperatives now organize the supply of farm inputs, water distribution and irrigation system maintenance. They also

*In Niger, researchers made significant progress in diagnostic research at three irrigation schemes.*

market farmers' produce, but in so doing must set aside a proportion of the profits to invest in inputs for the next season, since they cannot legally obtain credit.

Frequently under pressure from the very same donors that in the past promoted irrigation development, the Government of Niger is being told to reduce its role in this area, as well as in irrigation management. While farmers accept this reality they are finding it difficult to fill the void left by the state.

## THE PROGRAM

IIMI's program in Niger consists mainly of a single project supported by the African Development Bank (AfDB). The objectives of this project are to identify ways of reducing operating costs, diversifying crops and generally improving management in farmer-managed irrigation schemes along the Niger River. The project also pays special attention to the role of women in irrigated agriculture, and to the environmental effects of irrigation. It works under three national ministries: the Ministère de l'Agriculture et de l'Elevage (MAG/EL); the Ministère de l'Hydraulique et de l'Environnement (MHE) and the Ministère de l'Education Nationale, de l'Enseignement Supérieur et de la Recherche (MEN/SR). There are four national partners: the Office National des Aménagements Hydro-Agricoles (ONAHA), the Institut National de la Recherche Agronomique du Niger (INRAN), the Génie Rural (GR), and the University of Niamey (Faculté d' Agronomie). A seven-member committee steers and coordinates project activities.

The parastatal ONAHA is currently undergoing radical reorganization. Although the final outcome remains uncertain, it will probably relinquish its roles in irrigation construction and rehabilitation to focus exclusively on providing support services to cooperatives (see page 31).

The project was approved by the government in July 1991 and field research began in January 1992. Three representative irrigation schemes were selected to host field research and training activities—Saga, Kourani-Baria and Tillakaina.

## ACTIVITIES IN 1993

During the year, the program made significant progress in its diagnostic research at all three schemes. The initial findings of this research were given in IIMI's 1992 Annual Report. Through the more detailed studies now being carried out it is becoming increasingly apparent that the schemes' major constraints center round management at the perimeter level and the organization of cooperatives.

Research has also revealed the competition between rain-fed and irrigated agriculture. As in

neighboring Burkina Faso, farmers usually give priority to their rain-fed crops, leading to inefficient irrigation operations. A major future thrust of the program will be to develop solutions to this basic constraint.

Annually, the program hosts a number of students researching various topics under the joint supervision of university and project staff. Most students examine in more detail issues arising from the diagnostic research undertaken by the project.

One such topic, the role of women in irrigated agriculture, evolved into a 6-month core add-on project funded by the IIMI Gender Program. This project undertook further analysis on gender patterns in the organization of irrigated agriculture and irrigation management (see page 50). It also examined links between the performance of irrigation systems and gender relations in society. An additional output expected from the project is the identification of the gender-related training and information needs of government and nongovernment organizations working in Niger.

In mid-1993, the project conducted three 1-week courses for a total of about 50 ONAHA perimeter directors. The courses were held in Niamey, Birni n'Konni, and Tillabery. Special emphasis was placed on the provision of better support and advisory services to cooperatives. At one of the courses a professor of rural socioeconomics at the University of Niamey presented preliminary findings on the roles of women in irrigated agriculture. These findings were derived from the gender studies mentioned above.

Four 1-year grants are available to send young engineers to the regional Ecole Inter-Etats des Ingénieurs de l'Equipement Rural (EIER) in Ouagadougou for further training. One engineer who completed his training in 1993 subsequently chose to undertake more field work with the IIMI project. Two other candidates were recently selected and enrolled in the same program.

A 2-year research grant is available to an engineer, researcher or teacher at the University of Niamey's Faculty of Agronomy to work with the IIMI project on issues of mutual interest. A 1-year research grant was recently awarded to the project's soil scientist. This will enable him to move from half- to full-time sabbatical status, providing an opportunity to complete research on soil fertility and salinization.

In 1993, the project hosted a visit from IIMI's program in Nigeria, whose staff wished to study organizational aspects of the Saga Scheme. It also provided training to visiting engineers studying at EIER and a group of engineers visiting from Guinea. Lastly, the program hosted a Nigerien student in agricultural economics from Purdue University, who undertook field research for his M.Sc. thesis, on the economics of rice-based rotations in Niger. This student was sponsored by the West Africa Rice Development Association (WARDA) and funded by the AfDB.

The program sent its training officer on a 2-month course in France to strengthen his skills in organizing training activities. Other staff members will continue to benefit from short-term training courses in the future.

A further issue of the West African Irrigation Network Newsletter was published in French and English. This newsletter is a copublication with the Burkina Faso country program. The Niger program meets half the costs of publishing and periodically contributes articles. The project also prepared various technical reports. Students from the Faculty of Agronomy at the University of Niamey, and at least one faculty member, produced several reports with project support and under project staff supervision.

# Nigeria

## THE CONTEXT

Nigeria has more irrigated land and greater potential for irrigation expansion than any other West African country. About 90 percent of its irrigated area consists of traditional irrigation systems and 10 percent modern.

Public-sector irrigation development and management are the responsibility of the country's 11 River Basin Development Authorities (RBDAs). When they were created, in 1976, these parastatal agencies of the federal government were given responsibility for all agricultural production activities within their designated river basin area.

In 1987, the Government of Nigeria adopted a policy to commercialize public-sector irrigation, as part of a broader package of reforms undertaken in the context of structural adjustment. While the government continues to provide funds for the development of irrigation infrastructure, the cost of services provided by the RBDAs is no longer subsidized but must be borne by the beneficiaries.

This policy entails far-reaching changes, including institutional reorganization, legal reforms and the development of users' organizations. Increasingly, responsibilities for operating and maintaining systems are being shared between farmers and agencies. Changes have taken place in the scope and management of the RBDAs. They have been partially commercialized and agricultural production activities have been withdrawn from their mandate.

Both the size of Nigeria's irrigated sector and these rapid changes in management make the country an important one for IIMI, allowing opportunities both to study the process of change and to provide inputs from experiences elsewhere that will help to guide that process and ensure its successful outcome.

## THE PROGRAM

IIMI established its field office in Kano, Northern Nigeria, in August 1991, at the invitation of the Federal Ministry of Water Resources. The program aims to promote farmer participation in the management of public-sector irrigation. It works in collaboration with the Hadejia-Jama'ara River Basin Development Authority (HJRBDA). The collaborative research forms part of the Kano River Irrigation Project (KRIP), and is funded by the Ford Foundation.

The action research undertaken by the program in support of turnover in KRIP will be used as a model to assist other RBDAs in establishing similar participatory management systems. Activities focus on institutional aspects, modes of management, operation and maintenance methods, and the mobilization of labor and other resources. IIMI staff work closely with HJRBDA and KRIP to create the legal basis for joint management and to develop procedures for the formation of water users' associations. Special attention is devoted to the collection of water charges, with the aim of increasing the success rate in this area. Data are collected at three pilot sites in the head, middle and tail sections of KRIP on the socioeconomic status of farmers, on the crops they grow, their access to water, the moisture status of soils and growing crops, and the development and activities of water users' associations. This project is now in its second phase.

## ACTIVITIES IN 1993

During the year, IIMI continued its studies in KRIP. HJRBDA is now providing strong institutional support for the formation of water users' associations. The authority has established units both at its own headquarters and within KRIP to

*In Nigeria, IIMI continues its studies in the Kano River Irrigation Project.*

promote and support new associations. It has also established a review committee to monitor the units' activities. Staff have been assigned to promote associations in the project area. The Board of HJRBDA has confirmed its support for these activities. In some cases, users' associations are now officially registered; in others, an agreement between the association and the agency on the sharing of responsibilities has been signed.

The associations formed at the three pilot sites have led to various physical improvements to the system, better hydraulic performance, a higher collection rate for water charges, shorter irrigation times and increased crop area. These findings are discussed in more detail on page 40.

Activities are now under way to gain a better understanding of the water distribution system at the pilot sites. Measurements are being made at 51 inlets on seven distributaries and sub-distributaries. This exercise will continue until the end of the 1993/94 dry season. The results will throw light on the efficiency of operations under the new management arrangements. It is important that the crucial relationship between the agency and the associations gets off to a good start.

An important issue facing the future of the program is how water users' associations can be created and sustained in areas where irrigators do not own the land they cultivate. This issue has been the subject of discussion with policymakers during the year.

A study of *fadama* irrigation systems was launched during the year. *Fadamas* are depressions used for irrigated rice in the rainy season and for grazing livestock in the dry season.

The program's activities have led to considerable spin-off, including initiatives to start water users' associations in other systems, both within and outside KRIP. This spin-off is described on page 41 of this report.

In collaboration with the Ilorin University, IIMI organized a national seminar on Irrigation Research Priorities in Nigeria, held at Kano in April 1993. The seminar recommended that a national irrigation research network be set up to disseminate research results and other relevant information among its members. The proceedings of the seminar were published in June.

## Latin America and the Caribbean

This region of the developing world contains abundant, well-watered land. The area under irrigated agriculture in Latin America is about 16 million hectares, which is about 8–10 percent of the total irrigated area in developing countries. The major irrigation countries of this region are Mexico, Brazil, Argentina, Chile, Peru, Cuba, Ecuador and Colombia.

IIMI's operations in Latin America are at an early stage. Guidelines for the development of a program were established following an exploratory mission in 1991. In 1993, further progress was made in building a program in accordance with these guidelines.

In Colombia, a -month study on management transfer is now under way. The study is comparing the performance of two irrigation systems - Coello and Saldaña - before and after turnover. It is also studying the results of turnover in eight other systems in which it has already taken place. Preliminary results are reported on page 43.

In Chile, an irrigation official of the Irrigation Department, Ministry of Public Works was contracted to write a report describing the management transfer process in that country. The report has been submitted and is now being reviewed by IIMI.

The year also saw preparations for the start-up of collaborative research in Mexico. Following two missions to that country in July and October, memoranda of agreement were signed with two national partner institutions, the CP (Colegio de Postgraduados) and INIFAP (Institutuo Nacional de Investigaciones Forestales y Agropecuarias). The main theme of this research will be management turnover, but in the case of INIFAP other themes will be pursued as well. A research agenda for 1994 has been developed with both institutions. The Centro Internacional de Mejoramiento di Mais y Trigo (CIMMYT) has agreed to provide an administrative "umbrella" for IIMI staff involved in Mexican activities. Efforts are under way to hire an Irrigation Specialist to be posted to Mexico in early 1994.

Several publications appeared in Spanish and were distributed during 1993. They include the Consultancy Report of 1992 that established the program's guidelines, FMIS Newsletter Nos. 11 and 12, IIMI Review Vol. 6 No. 2 and Vol. 7 No. 1, and the Proceedings of a Workshop on Farmer-Managed Irrigation Systems, held at Mendoza, Argentina in 1991. Other publications were earmarked for translation in the near future.

# CAPACITY BUILDING

IIMI's capacity building activities are designed to strengthen national irrigation management and research. They are of two major kinds—training and information.

### MANAGEMENT TRAINING

Since 1990, IIMI has participated in a joint program with the Deutsche Stiftung fur Entwicklung (DSE) designed to upgrade the skills of irrigation managers in four countries of Southeast Asia: Indonesia, Malaysia, the Philippines and Thailand. Over the 4 years of the program nearly 20 events have been held, involving some 500 participants.

IIMI's major contribution has been to provide a program coordinator to work with the DSE project leader in planning and implementing the program.

This has involved an annual meeting to select subjects, locations and formats for the year's events, choose participants and resource persons for each event, and draft the detailed specifications of the subject areas to be covered.

Since the beginning of the program, about 17 international staff members of IIMI have participated actively at a DSE/IIMI event. The synthesis of ideas emerging from several of these events has been of considerable benefit to IIMI.

Five events were held in 1993. One was at national level, an Indonesian workshop on diagnosing training needs and designing training and teaching programs for irrigation management. The other four were all regional events. The first was a workshop on the rehabilitation and modernization of irrigation systems. This was an intensive interaction with experienced senior managers. The output from this was used to define the content of the second event, which was a regional course on the same subject. The other two regional events were a training course on the assessment of irrigation performance, and a workshop on the institutional framework for irrigation management.

The program is now approaching its end. No further events will be held in 1994, which will be devoted primarily to evaluation. Preliminary evaluations after each event suggest a high level of satisfaction on the part of participants from all four countries.

During the year, the management training program in Malaysia concluded based on which a publication titled " Irrigation Management Training for Institutional Development: A Case Study from Malaysia" is in the process of publication. IIMI has been involved in Malaysia since 1989, when the Department of Irrigation and Drainage (DID) requested the Institute's assistance in a comprehensive review of its approach to management. Based on the Malaysia experience, similar exercises were initiated in Bangladesh and in Sudan.

IIMI's participation in a collaborative training program and a conference organized by the International Rice Research Institute (IRRI) during 1993 opens up possibilities for collaboration with IRRI in training practitioners and mangers in improved management of irrigation.

In addition to the organizational activities mentioned above, training courses for irrigation professionals, regional and international workshops and conference have been carried out as a means for professional development.

In Tamil Nadu, India, IIMI facilitated a workshop in 1993 aimed at bringing together representatives from government water resources management agencies and research institutions.

## INDIVIDUAL TRAINING

In the area of individual training, IIMI hosted 30 fellowships and scholarships whose details are given in Annex III. These training activities were carried out in several countries including Sri Lanka, Pakistan, Burkina Faso and Nepal.

## COLLABORATIVE RESEARCH ACTIVITIES

IIMI works to strengthen national research institutions by tailoring collaborative research activities in the field. These collaborative studies are a key element in IIMI's training activities.

In 1993, collaborative research activities were initiated in several countries, some examples of which are given below.

## AGREEMENTS AND RESEARCH CONTRACTS

| *Organization* | *Purpose* |
|---|---|
| **Bangladesh** | |
| Bangladesh Agricultural Research Council (BARC) | To renew memorandum of agreement with BARC for IIMI to operate in Bangladesh. |
| Ministry of Agriculture | To collaborate on a study of Minor Irrigation Privatization. |
| **France** | |
| Centre National du Machinisme, du Genie Rural, des Eaux et des Forêts (CEMAGREF), Montpellier | To collaborate on five-year research on:<br>(1) Decision support for canal operation and maintenance.<br>(2) Economical analysis methods and tools for irrigation management.<br>(3) Monitoring of environmental and agricultural changes in irrigation systems through the use of GIS Remote Sensing, Data-Bases. |
| **India** | |
| Indian Institute of Management, Ahmedabad | To jointly carry out a study of irrigation management transfer in India. |
| Water and Land Management Institute (WALMI), Gujarat | To develop a management information system for performance monitoring in Mahi-Kadana System, Gujarat, India. |
| **Malaysia** | |
| Mudla Agriculture Development Authority (MADA) | To carry out a Collaborative Program on Management Innovations and the Performance of Irrigated Agriculture. |
| **Nepal** | |
| Irrigation Management Systems Studies Group and Institute of Agriculture and Animal Sciences | To conduct an irrigation resource inventory in the Northeast portion of Tanahun District using the methodology developed by IIMI-Nepal. |
| Hydro-Engineering Services and Nepal Consult (P) Ltd. | To conduct an inventory study of irrigation systems in the Marshyangdi River Catchment of Lamjung District. |
| Hydro-Engineering Services and Nepal Consult (P) Ltd. | To conduct an inventory study of irrigation systems in the Babai River Catchment of the Dang District. |
| Center for Rural Technology | To conduct farmer leaders' training on organizational procedures and processes in order to establish water users based NGOs. |

| Organization | Purpose |
|---|---|
| Center for Rural Technology | To organize the directory of water-user-based NGOs in 10 districts. |
| NGO Forum | To publish on a quarterly basis for one year, a newsletter that will serve as the information media for the promotion of water-user-based NGOs. |
| **Netherlands** | |
| International Institute for Infrastructural, Hydraulic and Environmental Engineering (IHE) and International Institute for Land Reclamation and Improvement (ILRI) | To carry out a five-year collaborative program entitled "Research Program on Irrigation Performance." |
| **Pakistan** | |
| Water and Power Development Authority (WAPDA), Lahore | To participate in the six member Umbrella Technical Group for developing an integrated research plan for the Fordwah Eastern Sadiqia (South) Irrigation and Drainage Project. |
| **Philippines** | |
| NIA Consult | To conduct a study tour for five DOI, Nepal Engineers in participatory management and irrigation resource inventory as part of the District Strengthening Project. |
| **Sri Lanka** | |
| Agrarian Research and Training Institute | To carry out data collection and analysis for monitoring and evaluation of the Participatory Irrigation System Management Policy. |
| Agrarian Research and Training Institute | To undertake the component of Land Development and Settlement, Infrastructure and Socioeconomic conditions of the KOISP ImpactAssessment Study. |
| Land Use Policy Planning Division | To undertake the preparation of a land plan for Huruluwewa and Nilwala watersheds under the SCOR Project. |
| Irrigation Department | To provide technical assistance to Irrigation Research Management Unit, SLFO Project. |
| Institute of Computer Technology | To establish the nature of current accounting and budgeting systems and its problems. |
| **Sudan** | |
| Ministry of Irrigation and Water Resources | To renew memorandum of agreement between IIMI and the Government of Sudan. |

## WORKSHOPS AND CONFERENCES

Workshops and conferences contribute towards the exchange of information and ideas between countries on new thinking and current experiences in the field of irrigation management. In 1993, IIMI organized or co-organized workshops and conferences in several countries including Sri Lanka, Burkina Faso, Sudan, Pakistan and Nepal. The Institute was also represented at several workshops and conferences organized by other institutions. The details of these events are given below.

### WORKSHOPS AND CONFERENCES ORGANIZED OR CO-ORGANIZED BY IIMI

| *Title* | *Date* | *Location* |
|---|---|---|
| Le Management de l'Irrigapion {Training Course on Irrigation Management (*co-organizer:* ETSHER, Ouagadougou, Burkina Faso)} | 4–16 January | Ouagadougou, Burkina Faso |
| Quel Environnement pour le Développement de l'Irrigation au Burkina Faso? (What Context for the Development of Irrigation in Burkina Faso?) (*co-organizers:* Burkina Faso Ministry of Water and Burkina Faso Association of Management) | 1–3 February | Ouagadougou, Burkina Faso |
| Third Progress Review and Coordination Workshop of the IMCD Research Network (*co-organizers:* BARC and BAU) | 8–11 February | Dhaka, Bangladesh |
| Irrigation Management Improvement Project: Mid-Project Review and Planning Workshop (*co-organizers:* HR Wallingford, U.K. and Irrigation Department, Sri Lanka) | 10–11 February | Waikkal, Sri Lanka |
| Irrigation Management in the Fordwah/Eastern Sadiqia Area | 15 February | Bahawalnagar, Paksitan |
| Crop-Based Irrigation Operation Project (*co-organizers:* IIMI-Pakistan and Asian Development Bank) | 14–15 March | D.I.Khan, Pakistan |
| From Farmers' Fields to Data Fields and Back: A Synthesis of Participatory Approaches to Resource Information Systems (*organizers:* IAAS/IU/Ford Foundation/IIMI/ILO/UNDP) | 21-26 March | Rampur, Chitwan, Nepal |
| Improving Irrigation Operation and Maintenance through Decisikn Support Technology | 30 March | Faisalabad, Pakistan |
| Irrigation System Management Research (ISMR) Symposium (*co-organizers:* Government of Pakistan and USAID, Islamabad) | 11–13 April | Lahore, Pakistan |
| Decision Support Systems for Improved Irrigation System and Water Resources Management (*cosponsors:* IIMI-Pakistan and CADSWES) | 21–22 April<br>26–27 April | Lahore, Peshawar, Pakistan |
| 10th International Irrigation Symposium—Water Berlin Congress '93 (*organizer:* German Association for Water Resources and Land Improvement (DVWK), *co-organizers:* World Bank, FAO, ICID and IIMI) | 29–30 April | Berlin, Germany |

| Title | Date | Location |
|---|---|---|
| Training Program for Office National des Amenagements Hydro-Agricoles (ONAHA) Perimeter Directors on Irrigation Management | 14 June 02 July | Niamey, Birni N'Konni, Tillabery, Niger |
| Workshop on Performance Assessment of Rahad Irrigated Scheme | 19–20 June | Wad Medani, Sudan |
| DSE/IIMI Workshop on Diagnosing Training Needs and Designing Training Programs for Irrigation Management in Indonesia | 21 June 25 July | Yogyakarta, Indonesia |
| DSE/IIMI Workshop on Majagement of Rehabilitation and Modernization of Irrigation systems | 5–9 July | Manila, Philippines |
| DSE/IIMI Workshop on Planning, Monitoring and Evaluation of Irrigation Performance | 12–30 July | Baguio City, Philippines |
| Workshop on Use of Computer Models as Decision Support Tools in Operation and Management of Irrigation Systems: Sri Lanka Experience (*organizers:* IRMU/IIMI) | 15–16 July | Galgamuwa, Sri Lanka |
| Workshop on Training Needs Assessment and Organizational Constraints Assessment | 7–19 August | Wad Medani, Sudan |
| Planning Workshops on Shared Control of Natural Resources | 23 Sep. – 25 Oct. | Colombo, Huruluwewa, Anuradhapura, Morawaka, and Galle, Sri Lanka |
| DSE/IIMI Course on Management of Rehabilitation and Modernization of Irrigation Systems | 4–22 October | Chiang Mai, Thailand |
| Workshop for Delivery of Training Needs Assessment and Organizational Constraints Assessment (TNA) Results | 23–28 October | Wad Medani, Sudan |
| Workshop on Catchment Management Study and Study on Performance Monitoring of the Automatic Flow and Water Level Downstream Control Strqctures (*organizers:* IRMU/IIMI) | 26 October | Colombo, Sri Lanka |
| Workshop on Strategic Plan and Medium Term Research Program of IRMU | 28 October | Colombo, Sri Lanka |
| DSE/IIMI Workshop on Institutional Framework for the Management of Irrigation | 1–5 November | Chiang Mai, Thailand |
| DSE/IIMI Course on Training Materials for Irrigation Management Systems. | 19 November 17 December | Chiang Mai, Thailand |
| Information Techniques for Improving the Management of Water in Irrigation Schemes (*organizers:* IIMI/CEMAGREF/IMTA) | 6–10 December | Colombo, Sri Lanka |
| Le Management de l'Irrigation (Training Course on Irrigation Management) (*co-organizer:* ETSHER, Ouagadougou, Burkina Faso)) | 6–18 December | Ouagadougou, Burkina Faso |

| Title | Date | Location |
|---|---|---|
| Training Program on Research Methodology (*organizers:* IRMU/IIMI) | 13–17 December | Galgamuwa, Sri Lanka |

## SELECTED WORKSHOPS AND CONFERENCES AT WHICH IIMI WAS REPRESENTED

| | | |
|---|---|---|
| Workshop on Mahaweli Restructuring Project (*organizer:* Ministry of Lands, Irrigation and Mahaweli Development) | 20 May | Colombo, Sri Lanka |
| Asian Regional Symposium on Maintenance and Operation of Irrigation and Drainage Schemes for Improved Performance (*organizers:* HR Wallingford, UK, DFA/MWR/PRC) | 24–26 May | Beijing, China |
| Workshop on Inland Valleys Research in Sub-Saharan Africa (*organizer:*WARDA) | 8–10 June | Bouake, Cote d'Ivoire |
| Les zones humides au Burkina Faso (Wetlands in Burkina Faso) (*organizer:* IUCN) | 30 June – 02 July | Ouagadougou, Burkina Faso |
| Annual General Meeting and Seminar of Sri Lanka Agricultural Economics Association | 12 June | Peradeniya, Sri Lanka |
| Fourth Annual Common Property Conference (*organizer:* IASCP) | 16–19 June | Manila, Philippines |
| The American Society of Agricultural Engineers' Summer Meeting (*organizers:* American USA Society of Agricultural Engineers and Canadian Society of Agricultural Engineers) | 20—3 June | Spokane, Washington |
| 61st Meeting of the Technical Advisory Committee (TAC) of the CGIAR | 28 June – 06 July | Colombo, Sri Lanka |
| La mise en valeur des aménagements hydro-agricoles de petite et moyenne taille, (Development of small and medium-scale irrigation schemes) (*organizers:* Ministry of Water and Ministry of Agriculture and Animal Resources, Burkina Faso) | 26–29 July | Ouagadougou, Burkina Faso |
| Annual Convention of the Japanese Society of Irrigation, Drainage, and Reclamation Engineering (organizer: Japanese Society of Irrigation, Drainage, and Reclamation Engineering) | 22 July | Tokyo, Japan |
| Seminar on Improvement of Farm-Level Infrastructure (*organizer:* Asian Productivity Organization) | 31 August – 10 Sep. | Tokyo, Japan |
| FAO Expert Consultation on Irrigation Water Delivery Models (*organizer:* FAO) | 4–7 October | Rome, Italy |
| Canal Lining and Seepage (*co-sponsors:* Hydraulic Research, Wallingford, U.K./IWASRI) | 18–21 October | Lahore, Pakistan |
| 62nd Meeting of the Technical Advisory Committee (TAC) of the CGIAR | 18–22 October | Washington, USA |

| Title | Date | Location |
|---|---|---|
| Environmental Assessment and Management of Irrigation and Drainage Projects for Sustained Agricultural Growth (*organizer:* CEWRE) | 24–28 October | Lahore, Pakistan |
| International Centers Week of the CGIAR | 25–29 October | Washington, USA |
| Use of Remote Sensing Technology for Irrigation and Drainage (Invited Experts Workshop) (sponsors: CEMAGREF and UNFAO) | 2–4 November | Montpellier, France |
| International Conference on Environmentally Sound Water Resources Utilization (*organizers:* IWRA and AIT) | 8–11 November | Bangkok, Thailand |
| Gender and Water Resources Management: Lessons Learned and Strategies for the Future (*organizer:* SIDA) | 1–3 December | Stockholm, Sweden |
| Water Management: India's Groundwater Challenge | 14–16 December | Ahmedabad, India |

# INFORMATION

IIMI's information activities are designed to disseminate research findings and experience to IIMI research staff and their partners, and also to others with an interest in irrigation management, including policymakers and donors.

The information office incorporates Editorial and Production Services, Library, Documentation, Public Awareness/Communications, Distribution, and Computer Services.

## ACTIVITIES IN 1993

The Editorial and Production Services group published a record 25 formal program publications during the year (Annex II) together with several brochures and a range of other institutional documents. The 1993 *IIMI Review*, published mid-year, focused on IIMI's management training programs, with special reference to the collaborative work completed recently in Malaysia. This periodical has been translated into Spanish and French, a procedure which is to become standard practice in future.

IIMI's library holdings increased by 1,587 items during the year including 147 unpublished monographs, 489 articles and chapters in books, 583 journal articles and 8 audio-visual items. The number of items in the special repository of irrigation management documents was increased to 3,244. The library now subscribes to 103 periodicals, 6 abstracting journals and 7 electronic journals.

The selective dissemination of information to IIMI's research staff, based on individual profiles, continued this year, generating many requests for information.

The library and documentation staff participated in two local information networks, the Agricultural Information Network (AGRINET) and the Environment Library Network (ELINET). IIMI

hosted an AGRINET workshop on agricultural information technology from 8 to 12 March. Seventeen librarians and documentalists from the libraries of local agricultural institutions participated. IIMI's library and documentation staff presented a number of topics, including the development and use of electronic bibliographic databases and access to information through CD-ROMs.

At the beginning of the year, the computer services unit was brought under the Information Office. A plan for upgrading the PC-based applications and hardware was developed and implemented by mid-year. In spite of funding restrictions, IIMI managed to invest in a substantial replacement program which marked the beginning of decentralized networked computing which will continue throughout 1994.

# FINANCE AND ADMINISTRATION

In 1993, the Institute's income of US$9.3 million was applied to operating expenditures of $8.7 million (see Figures 12 and 13). Thus, IIMI ended the year with a net operating income of $582,294 of which $363,434 was allocated for new capital purchases, and the balance of $218,860 was allocated to the operating fund. In 1993, IIMI employed $3.4 million in core unrestricted resources, $2.8 million in core restricted support, and $3.1 million in complementary support. IIMI's unencumbered cash assets at the end of 1993 were over $2.3 million.

At the close of 1993, IIMI had 41 internationally recruited staff. Some 169 national professional and management staff were engaged in IIMI's research, training, and information activities in headquarters and overseas units. IIMI's total staff numbered 378, more than half of them based outside Sri Lanka (see Figure 14 in Annex IV).

The financial tables that follow distinguish between IIMI's core programs and complementary programs. The definitions adopted for the Medium-Term Plan are given in the appended table. Since the Medium-Term Plan period commences in 1994, a "transition definition" was adopted for 1992 and 1993. Under this "transition definition" all ongoing research activities carried out in India and Pakistan (whether country-specific or transnational) were considered part of IIMI's core prograi, rather than its complementary program.

IIMI defines as core those activities deemed essential for meeting the Institute's mission of fostering the development, dissemination and adoption of lasting improvements in the performance of irrigated agriculture in developing countries. These activities are those which:

- Involve research or research-related activities.
- Address one or more of IIMI's five program areas.
- IIMI is better-qualified to undertake than others.
- Generate transnational rather than country-specific results.

IIMI's complementary program covers activities of a similar type, but their results are country-specific rather than transnational in scope.

## CORE UNRESTRICTED, CORE RESTRICTED & COMPLEMENTARY—1993.

| *Donor* | | *1993 Grant (US$)* |
|---|---|---|
| **CORE UNRESTRICTED** | | |
| AUSTRALIA | ..... | 109,528 |
| CHINA | ..... | 10,000 |
| CIDA | ..... | 254,264 |
| EEC | ..... | 338,100 |
| FORD FOUNDATION | ..... | 350,000 |
| GERMANY | ..... | 298,425 |
| INDIA | ..... | 25,000 |
| JAPAN | ..... | 329,908 |
| NETHERLANDS | ..... | 266,272 |
| USAID | ..... | 350,000 |
| WORLD BANK | ..... | 1,000,000 |
| SUBTOTAL (UNRESTRICTED) | ..... | 3,331,497 |
| **OTHER REVENUE** | | |
| BANK INTEREST | ..... | 65,802 |
| SUNDRY INCOME | ..... | 21,362 |
| SUBTOTAL (OTHER REVENUE) | ..... | 87,164 |
| TOTAL CORE (UNRESTRICTED RESOURCES) | ..... | 3,418,661 |

| *Donor* | *Project* | *1993 Grant (US$)* |
|---|---|---|
| **CORE RESTRICTED** | | |
| ADB | Proposed Management Improvements to Undertake Crop-Based Irrigation Operations in NWFP, Pakistan | 150,977 |
| AFDB | Support for IIMI Research Programs in Africa | 190,000 |
| CEMAGREF | Mathematical Modeling/Flow Measurements for improving Canal Management | 19,204 |
| DANIDA | Gender Issues in Irrigation Management | 44,005 |
| FORD | Collaborative Research in India | 41,305 |
| FORD | Irrigation Management for Latin America—Phase I | 92,953 |
| FORD | Irrigation Management for Latin America—Phase II | 50,848 |
| FORD | Support for Research on Farmer Contributions to Irrigation Costs | 1,855 |
| FRANCE | General Support | 102,682 |

(Continued on page 86)

| Donor | Project | 1993 Grant (US$) |
|---|---|---|
| France | Model Applications at Kirindi Oya, Sri Lanka | 18,532 |
| Germany | Enhancement of Research on Irrigation and Drainage Technology (IPTRID) | 175,239 |
| Germany | Privatization and Self-Management of Irrigation | 484,233 |
| IFAD/BMZ | Assistance to Farmer-Managed Irrigation Systems—Phase II | 201,705 |
| Japan | Performance Assessment Program | 300,000 |
| Netherlands | Collaboration with ILRI & IHE | 182,401 |
| Netherlands | Gender Program | 21,093 |
| Netherlands | Waterlogging and Salinity Project, Pakistan | 416,380 |
| ODA | Collaboration with Hydraulics Research | 99,206 |
| Pakistan | Fordwah Sadiqia Project | 31,352 |
| USAID | Strengthening National Capacity to Improve the Performance of Irrigation Systems in Pakistan—Phase II | 156,210 |
| | Sub Total Restricted | 2,780,180 |
| | Total Core | 6,198,841 |

## COMPLEMENTARY

| | | |
|---|---|---|
| ADB | Monitoring & Evaluation of Participatory Irrigation and Systems Management | 284,832 |
| ADB | Proposed Management Improvements to Undertake Crop-Based Irrigation Operations in NWFP, Pakistan | 1,955 |
| ADB | Sri Lanka Technical Assistance—Phase II | 235,402 |
| ADB | Study on Privatization of Minor Irrigation, Bangladesh | 75,927 |
| AFDB | Irrigation Management Development in Burkina Faso | 209,588 |
| AFDB | Irrigation Management Development in Niger | 224,944 |
| EC | National Irrigation Rehabilitation Project (NIRP) | 365,909 |
| Ford | Bangladesh Study | 3,566 |
| Ford | Irrigation Management for Latin America—Phase II | 39,003 |
| Ford | Support for an Irrigation Management Program in Nigeria—Phase I | 55,891 |
| Ford | Support for an Irrigation Management Program in Nigeria—Phase II | 222,614 |
| Ford | Supplementary Support for Sudan | 147,982 |
| Ford | Support for Bangladesh | 143,676 |
| Ford | Support for Collaborative Activity in Nepal | 169,248 |
| ILO | National Workshop on Nongovernmental Organizations (NGOs) | 6,084 |
| JIRCAS | Tank Cascade Systems Study | 8,173 |
| Netherlands | Waterlogging and Salinity Project, Pakistan | 1,861 |
| Sri Lanka | Kirindi Oya Irrigation & Settlement Project | 19,839 |
| USAID | Strengthening National Capacity to Improve the Performance of Irrigation Systems in Pakistan—Phase II | 475,069 |
| USAID | Shared Control of Natural Resources (SCOR) | 412,125 |
| | Subtotal Complementary | 3,103,688 |
| | Total | 9,302,529 |

See ANNEX 1 for an explanation of the projects listed above

## CONSOLIDATED STATEMENT OF FINANCIAL POSITION
## AS OF 31 DECEMBER 1993 (US DOLLARS)

| ASSETS | Current Year 31/12/1993 | Prior Year 31/12/1992 |
|---|---|---|
| **Current Assets** | | |
| Cash and Cash Equivalents | 2,392,427 | 2,021,718 |
| Accounts Receivable: | | |
| Donors | 905,014 | 1,086,841 |
| Employees | 46,348 | 56,229 |
| Others | 310,910 | 199,300 |
| Inventories | 51,947 | 68,417 |
| Prepaid Expenses | 646,230 | 392,627 |
| TOTAL CURRENT ASSETS | **4,352,876** | **3,825,132** |
| Cash Collateral for PRI Loan | 365,218 | 308,897 |
| Deposit Against Finance Lease | 3,270 | 3,270 |
| **Fixed Assets** | | |
| Property, Plant and Equipment | 4,402,069 | 4,127,771 |
| Less: Accumulated Depreciation | 2,400,168 | 2,056,059 |
| TOTAL FIXED ASSETS — NET | **2,001,901** | **2,071,712** |
| TOTAL ASSETS | **6,723,265** | **6,209,011** |
| **LIABILITIES AND NET ASSETS** | | |
| **Current Liabilities** | | |
| Accounts Payable: | | |
| Donors | 2,024,217 | 1,766,628 |
| Others | 664,205 | 900,503 |
| Accruals and Provisions | 51,020 | 32,789 |
| TOTAL CURRENT LIABILITIES | **2,739,442** | **2,699,920** |
| Provision for Liabilities & Charges | 381,646 | 297,719 |
| Long-Term Liabilities | | |
| Program Related Investment Loan | 729,481 | 871,056 |
| Finance Lease - -Pakistan | 7,892 | 20,078 |
| TOTAL LIABILITIES | **3,858,461** | **3,888,773** |
| **Net Assets** | | |
| Capital Invested in Fixed Assets: | | |
| Center owned | 1,027,918 | 1,017,554 |
| In Custody | 116,662 | 48,857 |
| Capital Fund | 916,318 | 668,782 |
| Operating Fund | 803,905 | 585,045 |
| TOTAL NET ASSETS | **2,864,803** | **2,320,238** |
| TOTAL LIABILITIES & NET ASSETS | **6,723,264** | **6,209,011** |

*Source* 1993 Audited Accounts

*Figure 12. Income, 1984–93 (million US$).*

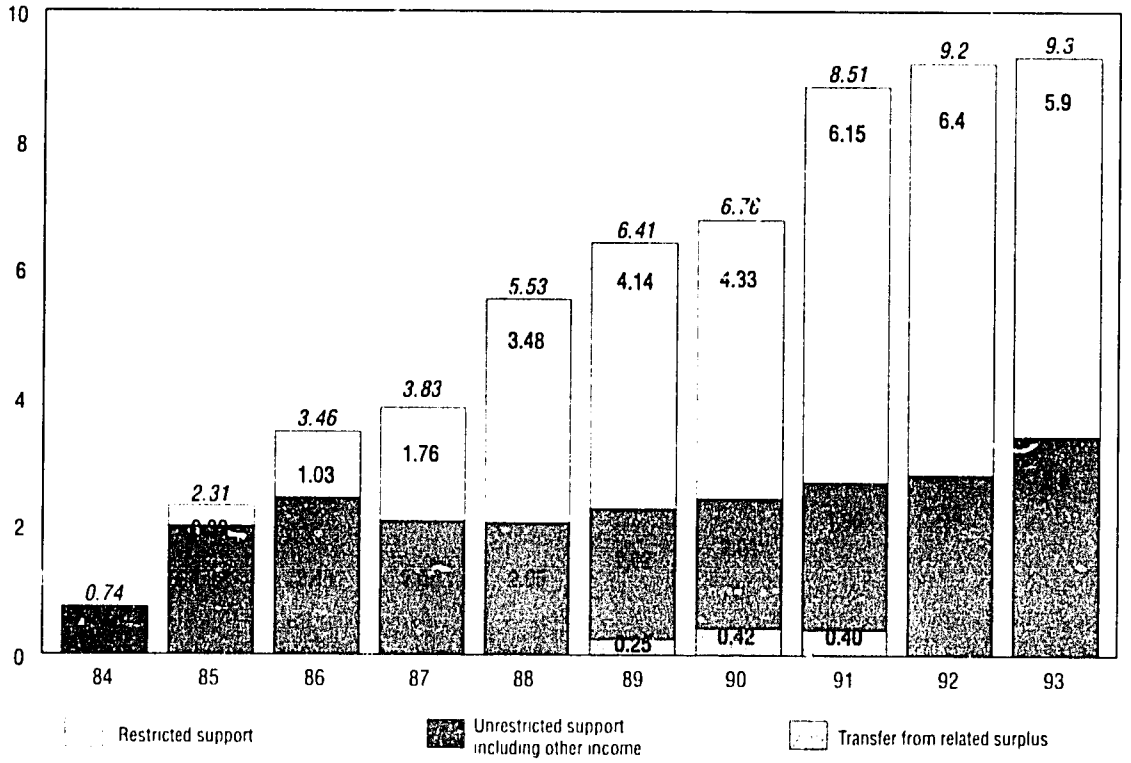
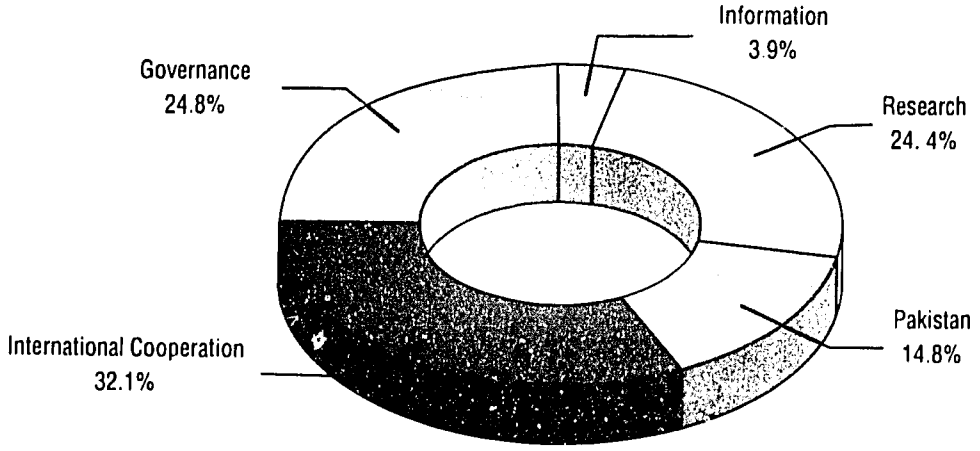



*Figure 13. Net Operating Expenditure, 1993.*




In Million US$

| | |
|---|---|
| Information | .34 |
| Governance | 2.16 |
| International Cooperation | 2.80 |
| Pakistan | 1.29 |
| Research | 2.13 |
| Total | 8.72 |

# ANNEX I
# RESTRICTED PROJECTS 1993

| Project | Donor | Pledged Amount* | Duration | Cumulative Expenditure to 31/12/1992 (US$) | Expenditure 1993 (US$) |
|---|---|---|---|---|---|
| **CORE RESTRICTED** | | | | | |
| PAKISTAN<br>To identify and assist in the implementation of proposed management improvements to undertake crop-based irrigation operations in North-West Frontier Province of Pakistan. | Asian Development Bank | 858,045 | 36 months | 575,490 | 150,977 |
| SUPPORT FOR AFRICA PROGRAM<br>Assist in financing the expenditure relating to the implementation of a program in Africa. | African Development Bank | UA 138,158 | 12 months | — | 190,000 |
| MATHEMATICAL MODELLING/FLOW MEASUREMENTS FOR IMPROVING CANAL MANAGEMENT<br>To develop and field-test a mathematical flow simulation model to study the hydraulic behavior of irrigation canals and also to serve as a decision-support tool for managing manually operated irrigation systems. | CEMAGREF | French Francs 135,000 | 11 months | 4,169 | 19,204 |
| GENDER ISSUES IN IRRIGATION MANAGEMENT<br>To increase the knowledge and understanding of gender issues in irrigation, especially the role of women in irrigated agriculture as well as its impact on women's lives. | DANIDA | 49,985 | 12 months | 4,329 | 44,005 |
| INDIA<br>To explore & initiate collaborative projects between IIMI & Indian institutions through research, professional development, and information exchange. This work is designed to strengthen the capacity of Indian institutions to contribute towards the improvement of irrigation systems. | Ford Foundation India | 200,000 | 67 months | 158,695 | 41,305 |
| IRRIGATION MANAGEMENT FOR LATIN AMERICA—PHASE I<br>Support to design and initiate irrigation programs in Latin America. | Ford Foundation New York | 300,000 | 24 months | 207,047 | 92,953 |
| IRRIGATION MANAGEMENT FOR LATIN AMERICA—PHASE I<br>Support to initiate collaborative research and action to improve irrigation systems in Mexico and to plan similar programs throughout Latin America. | Ford Foundation New York | 250,000 | 36 months | — | 50,848 |
| SUPPORT FOR RESEARCH ON FARMER CONTRIBUTIONS TO IRRIGATION COSTS<br>IIMI consultancy expenses—grant to Kasetsart University, Faculty of Economics and Business Administration. | Ford Foundation Thailand | 3,925 | 12 months | 2,070 | 1,855 |

*In US dollars unless otherwise stated

## ANNEX I *(Continued)*

| Project | Donor | Pledged Amount* | Duration | Cumulative Expenditure to 31/12/1992 (US$) | Expenditure 1993 (US$) |
|---|---|---|---|---|---|
| General Support<br>To support the "Sustainable Management of Water Delivery and Disposal" at Kirindi Oya. | France | French Francs 592,000 | 12 months | — | 102,682 |
| Model Applications at Kirindi Oya<br>To support research on main canal system management through the application of mathematical flow simulation models using microcomputers. | France | 142,000 | 36 months | 123,468 | 18,532 |
| Enhancement of Research on Irrigation and Drainage Technology (IPTRID)<br>To provide a framework for collaborative action for assessment of technology R&D needs; assist developing countries and external supporting agencies in identifying priorities in R&D related to irrigation & drainage technology; support the formulation of R&D policies & programs in the line with sectoral plans; facilitate training & exchange of information. | Germany | DM 900,000 | 36 months | 315,538 | 175,239 |
| Privatization and Self-Management of Irrigation<br>To support case studies to conduct research and development programs for turnover in selected countries where turnover is underway with a view to develop decision-support packages for Governments that are considering transfer to local management. Facilitate exchange of information among countries engaged in the turnover process. | Germany | DM 1,701,900 | 36 months | 64,101 | 484,233 |
| Assistance to Farmer-Managed Irrigation Systems —Phase II<br>For continuing research on farmer-managed irrigation systems with the aim of identifying and evaluating ways by which farmer-managed irrigation systems can be sustained and improved. | IFAD<br>Germany | US$150,000)<br>DM970,000) | 36 months | 542,809 | 201,705 |
| Performance Assessment Program<br>Support for the performance assessment program which aims to develop and validate generally accepted conceptual frameworks, methodologies and indicators that can be used for assessing and improving the performance of irrigated agriculture. | Japan | J.Yen 31,767,000 | 12 months | — | 300,000 |
| Collaboration with ILRI and IHE<br>Support for the performance assessment program which aims to develop & validate generally accepted conceptual frameworks, methodologies and indicators that can be used for assessing and improving the performance of irrigated agriculture. | Netherlands | 182,401 | 12 months | — | 182,401 |

*In US dollars unless otherwise stated

## ANNEX I *(Continued)*

| Project | Donor | Pledged Amount* | Duration | Cumulative Expenditure to 31/12/1992 (US$) | Expenditure 1993 (US$) |
|---|---|---|---|---|---|
| Gender Issues in Irrigation Management<br>To increase knowledge and understanding about the relationship between gender relations and the performance of irrigation systems. | Netherlands | DFL. 300,600 | 24 months | — | 21,093 |
| Waterlogging and Salinity Project, Pakistan<br>Support to IIMI Pakistan to implement, in collaboration with national agencies, a program of applied research on waterlogging and salinity. | Netherlands | DFL. 4,005,500 | 60 months | 1,688,580 | 416,380 |
| Collaboration with Hydraulics Research<br>Drainage and irrigation management improvement project. | Overseas Development Administration United Kingdom | Sterling Pounds 175,000 | 36 months | 157,441 | 99,206 |
| Fordwah Eastern Sadiqia (South) Irrigation and Drainage Project<br>The study of the services of IIMI Pakistan were contracted by WAPDA to collaborate in the proposed research and monitoring activities through the membership of the Umbrella Technical Group and for the preparation of an Integrated Research Plan | World Bank | 31,352 | 6 months | — | 31,352 |
| Irrigation Systems Management Project<br>To improve the capacity and relevancy of water management research in Pakistan. | USAID Pakistan | 895,759 | 22 months | 739,549 | 156,210 |
| Subtotal—Cori | | | | | 2,780,180 |

## COMPLEMENTARY

| | | | | | |
|---|---|---|---|---|---|
| Monitoring and Evaluation of Participatory Irrigation and Systems Management<br>To assist the Govt. of Sri Lanka and the irrigation agencies in the implementation of the Government's new participatory irrigation system management policy through comprehensive monitoring and evaluation of the Turnover Program being implemented in selected schemes. | Asian Development Bank | 595,000 | 24 months | 104,379 | 284,832 |
| Pakistan<br>To identify and assist in the implementation of proposed management improvements to undertake crop-based irrigation operations in North-West Frontier Province of Pakistan. | Asian Development Bank | 1,955 | 36 months | — | 1,955 |

*In US dollars unless otherwise stated

## ANNEX I *(Continued)*

| Project | Donor | Pledged Amount* | Duration | Cumulative Expenditure to 31/12/1992 (US$) | Expenditure 1993 (US$) |
|---|---|---|---|---|---|
| Sri Lanka TA—Phase II<br>To strengthen the long-term viability of irrigation systems and to optimize use of existing land, water and infrastructure resources through implementing, refining and evaluating management recommendations developed under Phase I for system management, operation and maintenance; system rehabilitation and improvement; and strengthening irrigation agencies and farmer organizations, with particular attention to the requirements for crop diversification. | Asian Development Bank | 750,000 | 27 months | 486,849 | 235,402 |
| Study on privatization on Minor Irrigation: Bangladesh<br>To assist the Government in reviewing the current status and impact of, and options and alternatives for, minor irrigation privatization, at the district and pump command area levels. | Asian Development Bank | 548,000 | 24 months | — | 75,927 |
| Burkina Faso<br>Program to strengthen the capacity of national institutions to improve and sustain the performance of small-scale reservoir-based village irrigation schemes through collaborative research. | African Development Bank | 877,117 | 48 months | 306,435 | 209,588 |
| Niger<br>Evaluation of performance of Farmer-Managed Irrigation Systems on the Niger River Valley. | African Development Bank | 770,342 | 48 months | 350,253 | 224,944 |
| National Irrigation Rehabilitation Project (NIRP)<br>To assist the Irrigation Department of Sri Lanka to identify research needs, support research programs which yield results of immediate interest to the irrigated agriculture sector and to assist the Irrigation Department of Sri Lanka to establish an Irrigation Research Management Unit (IRMU). | Commission of The European Communities | ECU 843,840+ SL Rupees 21,684,800 | 48 months | 193,156 | 365,909 |
| Bangladesh Study Tour<br>Study tour for two engineers from the Bangladesh Water Development Board (BWDB). | Ford Foundation Bangladesh | 3,566 | 12 months | — | 3,566 |
| Irrigation Management for Latin America—Phase II<br>Support for initiating collaborative action and research to improve irrigation systems in Mexico and to plan similar programs throughout Latin America. | Ford Foundation New York | 500,000 | 36 months | — | 39,003 |
| Nigeria—Phase I<br>Assist in developing a viable joint farmer-management model in the Kano River Project of the Hadejia-Jama'ara River Basin Development Authority (RBDA) | Ford Foundation New York | 425,000 | 24 months | 369,109 | 55,891 |
| Nigeria—Phase II<br>Support for an irrigation management program in Nigeria. | Ford Foundation New York | 325,000 | 24 months | — | 222,614 |

*In US dollars unless otherwise stated.

## ANNEX I *(Continued)*

| Project | Donor | Pledged Amount* | Duration | Cumulative Expenditure to 31/12/1992 (US$) | Expenditure 1993 (US$) |
|---|---|---|---|---|---|
| SUDAN<br>Supplementary support for an irrigation management program in Sudan. | Ford Foundation New York | 450,000 | 36 months | 71,802 | 147,982 |
| BANGLADESH<br>Partial support for an IIMI resident scientist to work on irrigation management in Bangladesh. | Ford Foundation Bangladesh | 394,000 | 36 months | 160,202 | 143,676 |
| SUPPORT FOR COLLABORATIVE ACTIVITY IN NEPAL<br>Support for IIMI to assist the Nepal Government in developing participatory programs for irrigation development. | Ford Foundation New York | 405,000 | 36 months | 235,752 | 169,248 |
| NATIONAL WORKSHOP ON NONGOVERNMENTAL ORGANIZATIONS (NGOs)<br>Workshop on the role of nongovernmental organizations in irrigation development and management. | International Labour Organization Nepal | 6,084 | 12 months | — | 6,084 |
| JAPAN INTERNATIONAL RESEARCH CENTER FOR AGRICULTURAL SCIENCES (JIRCAS)<br>Studies on improvement of irrigation management in minor tank cascade systems in the dry zone of Sri Lanka. | Japan | 8,173 | 12 months | — | 8,173 |
| WATERLOGGING AND SALINITY PROJECT, PAKISTAN<br>Support to IIMI Pakistan to implement, in collaboration with national agencies, a program of applied research on waterlogging and salinity | Netherlands | DFL. 3,500 | 60 months | — | 1,861 |
| KIRINDI OYA IRRIGATION AND SETTLEMENT PROJECT IMPACT ASSESSMENT STUDY (KOISP)<br>Study on crop and livestock management practices and the associated production marketing problems including the farm budgets and yields, forestry in KOISP, sanitation, water supply, nutrition and health aspects of the settlers/ settlement assessment of water quality, status of irrigation structures, and other irrigation-related subjects. | Sri Lanka | Rs.3,917,500 US$32,499 | 2 months | — | 19,839 |
| IRRIGATION SYSTEMS MANAGEMENT PROJECT<br>To improve the capacity and relevancy of water management research in Pakistan. | USAID Pakistan | 740,996 | 22 months | 265,927 | 475,069 |
| SHARED CONTROL OF NATURAL RESOURCES (SCOR)<br>To assist Sri Lanka to sustain the productivity of land and water resources within selected watersheds through shared control by local user groups and the government involving formal agreements and joint management. | USAID | 2,533,000 | 29 months | — | 412,125 |
| SUBTOTAL—COMPLEMENTARY | | | | | 3,103,688 |
| TOTAL—CORE AND COMPLEMENTARY | | | | | 5,883,868 |

*In US dollars unless otherwise stated.

# ANNEX II
# PUBLICATIONS 1993

## GENERAL PUBLICATIONS

International Irrigation Management Institute. Publications Catalog. Colombo, Sri Lanka: The Institute. 44p. (August). ISSN: 1018-4899

International Irrigation Management Institute. Irrigation Management Information Network (IMIN) Keyword Thesaurus. Colombo, Sri Lanka: The Institute. 56p. (February).

## SERIALS

International Irrigation Management Institute. A selected bibliography on irrigation management (Documents entered in the Irrigation Management Information Network database July-December 1991). Vol.5. No.2. Colombo, Sri Lanka: The Institute. 128p. (February). ISSN: 1015-1680

International Irrigation Management Institute. A selected bibliography on irrigation management (Documents entered in the Irrigation Management Information Network database in 1992). Vol.6. Colombo, Sri Lanka: The Institute. 232p. (November). ISSN: 1015-1680

## PERIODICALS

International Irrigation Management Institute. Annual Report 1992. Colombo, Sri Lanka: The Institute. 114p.(October). ISSN:1017-5954

International Irrigation Management Institute. IIMI Review. Vol.6.No.2 (Edición En Español). Colombo, Sri Lanka: The Institute. 24p. (November). ISSN: 1021-830

International Irrigation Management Institute. IIMI Review. Vol.7.No.1. Colombo, Sri Lanka: The Institute. 24p. (August). ISSN:1012-831X

International Irrigation Management Institute. IIMI Review. Vol.7.No.1. (Edición En Español). Colombo, Sri Lanka: The Institute. 24p. (November). ISSN: 1021-830

## NEWSLETTERS

International Irrigation Management Institute. FMIS. No.11. Boletín de la Red de Sistemas de Riego Administrados por los Agricultures. Publicado por el International Irrigation Management Institute. (Edición En Español). 28p. (October). ISSN:1021-0849

International Irrigation Management Institute. FMIS. No. 12. Newsletter of the Farmer-Managed Irrigation Systems Network. No.12. Colombo, Sri Lanka: The Institute. 32p. (October). ISSN:1012-988X

Institut International du Management de l'Irrigation. Bulletin du Réseau Irrigation Afrique de l'Ouest. (Newsletter of the West Africa Irrigation Network). No. 3. Burkina Faso/Niger, West Africa. (April). 40p. ISSN 1017-110X

Institut International du Management de l'Irrigation. Namanegdzanga—Irrigation et environnement. (National language newsletter on irrigation and the environment). No. 1. Ouagadougou, Burkina Faso. (February). 12p.

Institut International du Management de l'Irrigation. Namanegdzanga—Irrigation et environnement. (National language newsletter on irrigation and the environment). No. 2. Ouagadougou, Burkina Faso. (November). 16p.

## RESEARCH PAPERS

International Irrigation Management Institute. Advancements in IIMI's research 1992. A selection of papers presented at the Internal Program Review. Colombo, Sri Lanka: The Institute. 320p. (October). ISBN 92-9090-199-3

Murray-Rust, D. and Bart W. Snellen. Irrigation system performance assessment and diagnosis. Colombo, Sri Lanka: International Irrigation Management Institute, International Institute for Land Reclamation and Improvement, International Institute for Hydraulic and Environmental Engineering. 168p. (July). ISBN: 92-9090-192-6

Rao, P.S. Review of selected literature on indicators of irrigation performance. Colombo, Sri Lanka: International Irrigation Management Institute. 90p. (October). ISBN 92-9090-198-5

## COUNTRY PAPERS

### Pakistan

Bandaragoda, D.J. and M. Badruddin. Moving towards demand-based operations in modernized irrigation systems in Pakistan. Colombo, Sri Lanka: International Irrigation Management Institute. 56p. (IIMI Country Paper—Pakistan—No.5). (February). ISBN 92-9090-161-6

Bandaragoda, D.J. The role of research-supported irrigation policy in sustainable irrigated agriculture: An interpretive precis of the case of Pakistan. Colombo, Sri Lanka: International Irrigation Management Institute. 82p. (IIMI Country Paper—Pakistan—No.6). (October). ISBN 92-9090-163-2

### Philippines

Gonzales, Leonardo S. Management turnover of a pump irrigation system in the Philippines: The farmers' way. Colombo, Sri Lanka: International Irrigation Management Institute. 104p. (IIMI Country Paper—The Philippines—No.2). (March). ISBN 92-9090-170-5

### Sri Lanka

Abeysekera, W.A.T. Rehabilitation of irrigation systems in Sri Lanka: A literature review. Colombo, Sri Lanka: International Irrigation Management Institute. (IIMI Country Paper—Sri Lanka—No.11). 116p. (April). ISBN: 92-9090-156-X

Nijman, C. Irrigation decision-making processes and conditions: A case study of the Kirindi Oya Irrigation and Settlement Project. Colombo, Sri Lanka: International Irrigation Management Institute. (IIMI Country Paper—Sri Lanka—No. 9). 348p. (May). ISBN 92-9090-140-3

Sakthivadivel, R. and Douglas J. Merrey. Flow measurements at drop structures for irrigation systems management in Sri Lanka: Colombo, Sri Lanka: International Irrigation Management Institute. (IIMI Country Paper—Sri Lanka—No.10). 68p. (March). ISBN 92-9090-155-1

## WORKING PAPERS

Itakura, Jun and Charles L. Abernethy. Water management in a tank cascade irrigation system in Sri Lanka. First seasonal report of TARC-IIMI Joint Project 1991/1992 maha season. Colombo, Sri Lanka: International Irrigation Management Institute. 58p. (Working Paper No. 24). (November). ISBN 92-9090-300-7

Malik, M. Saleem and Pierre Strosser. Management of private tubewells in a conjunctive use environment: A case study in the Manawala Distributory Command Area, Punjab, Pakistan. Colombo. Sri Lanka: International Irrigation Management Institute. 48p. (IIMI Working Paper—Pakistan—No.27). (December). ISBN 92-9090-164-0

Muralidaran, V. and K.V.S.M. Krishna. The dynamics of irrigation system performance. A comparative study of two secondary canal reaches in Mahi-kadana, Gujarat. Colombo, Sri Lanka: International Irrigation Management Institute. 80p. (Working Paper No. 25). (December). ISBN 92-9090-301-5

Rey, J.; M. Hemakumara; S. Mohanrajah and M.H. Junaid. Introduction of monitoring activities at the main-canal level. A study of the Kirindi Oya Right Bank Main Canal—Maha 1991/1992. Colombo, Sri Lanka: The International Irrigation Management Institute. 76p. (Working Paper No. 23). (February). ISBN 92-9090-190-X

## ANNEX II *(Continued)*

Strosser, Pierre; M. Rana Afaq and Carlos Garces. Changes in water duties and their impact on agricultural production. The case of Girsal Minor. Colombo, Sri Lanka: International Irrigation Management Institute. 42p. (IIMI Working Paper—Pakistan—No.26). (December). ISBN 92-9090-165-9

### SHORT REPORTS

Badruddin, M. An overview of irrigation in Pakistan. Pakistan. The Institute. 28p. (March).

Johnson III, Sam H. and Peter Reiss. Short report series on irrigation management transfer number 1. Can farmers afford to use the wells after turnover? A study of pump irrigation turnover in Indonesia. Colombo, Sri Lanka: International Irrigation Management Institute. 24p. (April).

### PROJECT REPORTS

Institut International du Management de l'Irrigation. Projet Management de l'Irrigation au Burkina Faso: Bilan et synthèse des travaux 1991–1993 (Mid-term synthesis report 1991-1993, of the Burkina Faso irrigation management project), IIMI, Ouagadougou, Burkina Faso. 300p. (July)

Institut International du Management de l'Irrigation. Projet Management de l'Irrigation au Burkina Faso: Rapport d'activités année 2: 1992/93 (Activity report, year 2: 1992/93). IIMI, Ouagadougou, Burkina Faso. 43p. (July).

### CONSULTANCY REPORTS

Bertranou, Armando and Ernst Schulze. Guidelines for an IIMI program in Latin America. Colombo, Sri Lanka: International Irrigation Management Institute. 86p. (May).

Bertranou, Armando and Ernst Schulze. Guia para un programa del IIMI en America Latina. Colombo, Sri Lanka: Instituto Internacional de La Manejo de La Irrigacion. 92p. (October).

Schulze, Ernst. IIMI strategy review for Sub-Saharan Africa. Ouagadougou/Doorwerth: International Irrigation Management Institute. 82p. (October).

### MANUALS PREPARED BY IIMI AND NATIONAL IRRIGATION ADMINISTRATION (NIA), PHILIPPINES

Farmer Irrigators' Organization Program (FIOP)

Basic Leadership Development Course

Financial System Management

Financial Management System—Volume I

Financial Management System—Volume II

Designing and Managing Training Programs

Irrigation System Management

Provincial Irrigation Office-Irrigators' Association (PIO-IA) Interface on the Operation and Maintenance of Communal Irrigation Systems

Irrigation System Office-Irrigators' Association (ISO-IA) Interface on the Operation and Maintenance of National Irrigation Systems

### PROCEEDINGS OF IIMI'S WORKSHOPS AND CONFERENCES

Legoupil, J.C.; Hilmy Sally and A. Pouya. (Eds). Quel environnement pour le développement de l'irrigation au Burkina Faso? Proceedings of a national seminar- workshop. Ouagadougou, Burkina Faso, 1–3 February 1993. Ouagadougou, Burkina Faso: International Irrigation Management Institute. 223p. (May). ISBN: 92-9090-197-7

Manor, Shaul and Jorge Chambouleyron. (Eds). Performance measurement in farmer-managed irrigation systems. Proceedings of an International Workshop of the Farmer-Managed Irrigation Systems Network. Mendoza, Argentina, 12–15 November 1991. Colombo, Sri Lanka: International Irrigation Management Institute. 300p. (November). ISBN: 92-9090-193-3

Miranda, Senen M. and Amado R. Maglinao. (Eds.). Management arrangements for accommodating nonrice crops in rice-based irrigation systems. Proceedings of the First Progress Review and Coordination Workshop of the Research Network on Irrigation Management for Crop Diversification in Rice-Based Systems (IMCD). Quezon City, the Philippines, 10–14 December 1990. Colombo, Sri Lanka: International Irrigation Management Institute. 212p. (February). ISBN: 92-9090-162-4

Miranda, Senen M. and Amado R. Maglinao. (Eds). Irrigation management for rice-based farming systems in Bangladesh, Indonesia and the Philippines. Proceedings of the Tri-Country Workshop on Irrigation Management for Rice-Based Farming Systems. Colombo, Sri Lanka, 12–14 November 1990. Colombo, Sri Lanka: International Irrigation Management Institute. 370p. (October). ISBN: 92-9090-157-8

Miranda, S. and A.R. Maglinao. (Eds). Promoting crop diversification in rice-based irrigation systems. Proceedings of the Second Progress Review and Coordination Workshop of the Research Network on Irrigation Management for Crop Diversification in Rice-Based Systems (IMCD). Yogyakarta, Indonesia, 9–12 September 1991. Colombo, Sri Lanka: International Irrigation Management Institute. 176p. (November). ISBN: 92-9090-4

Nwa, E. and P. Pradhan. (Eds). Irrigation research priorities for Nigeria. Proceedings of a National Seminar. Ilorin, Nigeria, 20–23 April 1993. International Irrigation Management Institute. 104p. (May). ISBN: 978-2066-06-0

Pant, S.R.; A. Valera; U. Pradhan and S. Basnet (Eds). Proceedings of the National Workshop on Participatory Management in Agency-Managed Irrigation Systems in Nepal. Kathmandu, Nepal, 29–30 April 1992. Department of Irrigation and International Irrigation Management Institute Nepal Field Operations. 44p. ISBN: 92-9090-180-2N (Nepali language version)

## PUBLICATIONS BY IIMI STAFF IN OUTSIDE JOURNALS, CONFERENCE PROCEEDINGS, ETC.

Bandaragoda, D.J. Institutional framework for irrigation: Salient features of the South Asian situation, Chiang Mai, Thailand. Paper presented at the DSE/IIMI Workshop on Institutional Framework for Irrigation, Chiang Mai, Thailand, 1–6 November 1993.

Itakura, J.; Yuyama, Y. et al. Study on improvement of interconnected tank irrigation system in dry zone of Sri Lanka: Outline of study. Paper presented at the Annual Convention of the Japanese Society of Irrigation, Drainage and Reclamation Engineering, Tokyo, Japan, 22 July 1993.

Itakura, J. and Y. Yuyama. Study on water management of interconnected tank irrigation system in dry zone of Sri Lanka. Japanese Journal of Tropical Agriculture, Vol. 37 Extra Issue 1, pp 23–24. (in Japanese language).

Kijne, Jacob W. Environmentally sound water management: Irrigation and the environment. Paper presented at the International Symposium on Environmental Assessment and Management of Irrigation and Drainage Projects for Sustained Agricultural Growth. Lahore, Pakistan, 24–28 October 1993.

Merrey, D.J.; R. Sakthivadivel and N. Fernando. A methodology for assessing irrigation system performance: Cumulative relative water supply. Irrigation and Drainage Systems 7, 43–67, 1993.

Merrey, D.J.; D.H. Murray-Rust and E.J. Vander Velde. Impacts of lining, maintenance and operations on water delivery performance in Pakistan. Paper presented at Asian Regional Symposium on Maintenance and Operation of Irrigation/Drainage Schemes for Improved Performance, Beijing, China, 24–27 May 1993.

Merrey, D.J.; M.G. Bos; D.H. Murray-Rust, H.G. Johnson and W.B. Snellen. Methodologies for assessing the performance of irrigation and drainage management. Paper presented at the Workshop of the Working Group on Irrigation and Drainage Performance, at the 15th International Congress on Irrigation and Drainage (ICID), The Hague, The Netherlands, 30 August–11 September 1993.

## ANNEX II *(Continued)*


Merrey, D.J. Institutional contexts for managing irrigated agriculture. Keynote paper presented at DSE/IIMI Workshop on Institutional Framework for Irrigation, Chiang Mai, Thailand, 1–6 November 1993.

Merrey, D.J. Irrigation rehabilitation and modernization as socio-technical institutional strengthening programs. Paper presented at DSE-IIMI Workshop on Management of Rehabilitation and Modernization of Irrigation Systems, Manila, Philippines, 5–9 July 1993.

Pradhan, U. and G. Thapa. Recent irrigation policies and environmental sustainability in Nepal. Paper presented at the Fourth Annual Common Property Conference, Manila, the Philippines, 16–19 June 1993.

Pradhan, U. Farmer-to-farmer training as a way of assistance to the farmers on the improvement of irrigation systems. Paper presented at the workshop entitled "From Farmers' Field to Data Fields—and Back: A Synthesis of Participatory Approaches to Resource Information Systems", Rampur, Nepal, 21–26 March 1993.

Pradhan, U. Farmers' water rights and their relation to data collection and management. Paper presented at the workshop entitled "From Farmers Field to Data Fields—and Back: A Synthesis of Participatory Approaches to Resource Information Systems", Rampur, Nepal, 21–26 March 1993.

Rey, Jacques and Hilmy Sally. Analytical framework for transferring computerized decision-support tools to irrigation managers. Paper presented at the international conference on Environmentally Sound Water Resources Utilization, Bangkok, Thailand, 8–11 November 1993.

Rey, Jacques.; P.O. Malatere; and J.P. Baume. Use of a simulation model to improve the manual operation procedures of an irrigation canal. Paper presented at the Asian Regional Symposium on Maintenance and Operation of Irrigation/Drainage Schemes for Improved Performance, Beijing, China, 24–26 May 1993.

Rey, Jacques. Computer tools for in-seasonal water distribution management: An example of prototype development in Sri Lanka. Paper presented at the FAO Expert Consultation on Irrigation Water Delivery Models, Rome, Italy, 4–7 October 1993.

Sally, Hilmy and Laurent Compaoré. L'utilisation des zones humides pour l'agriculture: Le cas des barrages-retenues du Burkina Faso. Paper presented at the workshop on Wetlands in Burkina Faso, IUCN, Ouagadougou, Burkina Faso, 30 June – 02 July 1993.

Skogerboe, Gaylord V. and Muhammed Aslam. Basin planning framework for irrigation salinity management. Paper presented at the International Symposium on Environmental Assessment and Management of Irrigation and Drainage Projects for Sustained Agricultural Growth, Lahore, Pakistan, 24–28 October 1993.

Strosser, P. and R. Meinzen-Dick. Ground water markets in Pakistan: An analysis of selected issues. Paper presented at the workshop on Water Management: India's Groundwater Challenge, Ahmedabad, India, 14-16 December 1993.

Valera, A.; V. Mishra and Durga K.C. Gravel lining for improved maintenance. Paper presented at the Asian Regional Symposium on Maintenance and Operation of Irrigation/Drainage Schemes for Improved Performance, Beijing, China, 24–26 May 1993.

Wijayaratna, C.M. Role of farmer organizations in the improvement of farm-level infrastructure. Paper presented at the seminar on Improvement of Farm-Level Infrastructure, Asian Productivity Organization, Tokyo, Japan, 31 August–10 September 1993.

Wijayaratna, C.M. Shared control of natural resources: An integrated watershed management approach to optimize production and protection. Paper presented at the Annual General Meeting and Seminar of the Sri Lanka Agriculture Economics Association, Peradeniya, Sri Lanka, 12 June 1993.

Zwarteveen, M. Gender and irrigation management. Issues and challenges. Paper presented at the workshop on Gender and Water Resources Management. Lessons Learned and Strategies for the Future, Stockholm, Sweden, 1–3 December, 1993.

# ANNEX III
# FELLOWSHIPS AND SCHOLARSHIPS 1993

| Name | Dates | | Case Study | Location |
|---|---|---|---|---|
| **Ph.D. Research Fellowships** | | | | |
| Y. Dembélé | August<br>August | 1991 –<br>1994 | Optimisation de la gestion hydraulique d'une retenue d'eau. (Optimization of the hydraulic management of a reservoir.) | Burkina Faso |
| T.M.S. Pradhan | August<br>July | 1991<br>1993 | Design and management interactions in Banganga River Irrigation System, Pithuwa Irrigation System, and Mahakali Irrigation Project. | Nepal |
| **Master's Degree Research Fellowships** | | | | |
| N. Pradhan | October<br>February | 1993 –<br>1994 | Technical efficiencies of farmer-managed irrigation systems and agency-managed irrigation systems. | Nepal |
| O. Barreteau | July<br>August | 1993<br>1993 | Water allocation in a watercourse command area. | Pakistan |
| N. Riviere | May<br>December | 1993 –<br>1993 | IMIS Program in the Chistian Sub-Division Fordwah Canal Division. | Pakistan |
| T.P. Alwis | May<br>October | 1993 –<br>1994 | Environment engineering and management. | Sri Lanka |
| C. Devindra | October<br>September | 1993 –<br>1996 | Soil and water (field) engineering. | Sri Lanka |
| C. Docter | June<br>September | 1993 –<br>1993 | Organizational management performance of distributary channel organizations in Sri Lanka. | Sri Lanka |
| N.A. Sisirakumara | May<br>October | 1993 –<br>1994 | Environment engineering and management. | Sri Lanka |
| **Visiting Researchers** | | | | |
| G. Bassolé | July<br>May | 1992 –<br>1993 | Diagnostic hydraulique du périmètre irrigué de Gorgo. (Hydraulic diagnosis of the Gorgo Irrigation Scheme.) | Burkina Faso |
| C.A.O. Khalifa | September<br>January | 1993 –<br>1994 | Apport de la télédétection aérospatiale à l'étude de la dynamique de gestion des périmètres irrigués: cas de Mogtédo. (Application of remote sensing to the study of the evolution of irrigation systems: The case of Mogtédo.) | Burkina Faso |

## ANNEX III *(Continued)*

| Name | Dates | Case Study | Location |
|---|---|---|---|
| C. Mahaman | September 1993 – January 1994 | Application de la télédétection à l'étude de la dégradation du bassin versant, à l' envasement de la retenue et au suivi diachronique du plan d'eau de Dakiri. (Application of remote sensing to study the degradation of the watershed and the sedimentation of the Dakiri reservoir.) | Burkina Faso |
| A. Ouattara | April 1993 – June 1993 | Essai d'analyse de la compétitivité de la riziculture irriguée et sa contribution à l'autosuffisance en riz du Burkina Faso. (Analysis of the competitiveness of irrigated rice and its contribution to food self-sufficiency in Burkina Faso.) | Burkina Faso |
| S. Ouedraogo | October 1993 – May 1994 | Rentabilité de la production du haricot vert dans le périmètre irrigué de Savili. (The economics of bean production in the Savili Irrigation Scheme.) | Burkina Faso |
| S. Ouedraogo | March 1993 – January 1994 | Contribution à l'analyse diagnostic hydraulique du périmètre irrigué de Dakiri. (Contribution to the hydraulic diagnosis of the Dakiri Irrigation Scheme.) | Burkina Faso |
| L. Sory | June 1993 – December 1993 | Irrigation et consommation d'eau du riz au début de la campagne humide: Incidence du calendrier cultural. (Irrigation and water use for rice cultivation at the beginning of the wet season: Influence of the cropping calendar.) | Burkina Faso |
| Z. Zida | July 1992 – May 1993 | Etude de la gestion de l'eau sur le périmètre de Mogtédo. (Study of the water management in the Mogtédo Irrigation Scheme.) | Burkina Faso |
| M. Abdou | June 1992 – June 1993 | Soil-plant relationships on the Tillakaina Perimeter. | Niger |
| K. Gbiatene | September 1992 – February 1993 | Study on the process of integrating Nigerian women into the modern agricultural sector situated along the Niger River: Case of the Tillakaina Perimeter. | Niger |

## ANNEX III *(Continued)*

| Name | Dates | Case Study | Location |
|---|---|---|---|
| Y. Hamani | September 1992 – February 1993 | Production of green beans on the Tillakaina Perimeter, Agro-economic diagnostic analysis. | Niger |
| Z. Issoufou | June 1992 – June 1993 | Diagnostic research on agricultural techniques and the hydraulic and chemical behavior of soils on the Saga Perimeter. | Niger |
| F. Massalachi | September 1992 – February 1993 | Integrating women into irrigation schemes: Case of the Saga Perimeter. | Niger |
| H. Sedar H.C. | September 1992 – February 1993 | Study of cassava: Socio-agro-economic factors. | Niger |
| M.F. Khan | June 1993 – August 1993 | Exploring future possibilities and utility of training local talent in the use of GIS as a research tool on irrigation management. | Pakistan |
| G. Ayariga | October 1992 – March 1993 | On-farm water management — Impact of seepage and percolation (S and P) values on water scheduling. | Sri Lanka |
| R.Oskam | April 1993 – October 1993 | Evaluation of decision support systems for water management in irrigation systems in Sri Lanka. | Sri Lanka |
| | | Management assessment at Uda Walawe. | Sri Lanka |
| A.B. Abdalla | October 1991 – October 1993 | Irrigation system performance in the Rahad Scheme. | Sudan |
| H. Ali | May 1992 – September 1993 | Water performance along minors in the Rahad Scheme. | Sudan |
| C. Gideon | December 1992 – December 1993 | Water performance along majors of the Rahad Scheme. | Sudan |
| A.A. Mohammed | March 1992 – February 1993 | Management of field course "ABXX" in Rahad. | Sudan |

# ANNEX IV
# IIMI SENIOR STAFF 1993

(The country, in the case of internationally recruited staff, is given in italics)

## OFFICE OF THE DIRECTOR GENERAL

Lenton, Roberto — *Argentina*
Director General

Mohtadullah, Khalid — *Pakistan*
Deputy Director General

Nugawela, Dewaki
Executive Assistant

## PROGRAMS DIVISION

### Research Group

Kijne, Jacob — *The Netherlands*
Director, Research

Abernethy, Charles — *United Kingdom*
Senior Technical Advisor

Amarasekera, Nalini
Research Associate (until March)

Amarasinghe, Upali
Research Data Analyst

Bhatia, Ramesh — *India*
Program Leader, Performance (from June)

Dassenaike, Lalith
Research Associate

de Silva, Mary
Senior Secretary

Dhanasekera, D. M.
Research Officer (from August)

Ekanayake, E.M.A.
Research Officer (from December)

Gosselink, Paulus — *The Netherlands*
Associate Expert (seconded from the Directorate General International Cooperation (DGIS), Ministry of Foreign Affairs of the Government of the Netherlands)

Gunasinghe, L.H.R.M.
Research Officer (from July)

Hemakumara, H.M.
Research Officer

Imbulana, K.A.U.S,
Research Officer (from June)

Itakura, Jun — *Japan*
Assistant Irrigation Specialist (seconded from Japan International Research Center for Agricultural Science)

Johnson, Sam — *USA*
Program Leader, Local Management (from April)

Kloezen, Wim — *The Netherlands*
Associate Expert (seconded from the Ministry of Foreign Affairs, the Hague) (from June)

Merrey, Douglas — *USA*
Program Leader, Public Irrigation Organizations and Sector-Level Management

Murray-Rust, Hammond — *United Kingdom*
Senior Irrigation Specialist

Priyanthi Chandrika, T.A.
Research Officer (from July)

Ratnayake, R.M.P.
Research Officer (from November)

Rey, Jacques — *France*
Associate Irrigation Specialist

Samad, Madar
Assistant to the Director, Research

Somasundaram, Vasumathy
Administrative Officer

Svendsen, Mark — *USA*
Research Fellow[1]

Udawatte, S.K.
Research Officer (from July)

Vermillion, Douglas — *USA*
Irrigation Specialist

Wasantha Kumara, W.A.U.
Research Officer

Weerakoon, K.G.P.
Research Officer (from July)

Wolter, Hans — *Germany*
Irrigation Specialist[2]

Yashima, Shigeo — *Japan*
Irrigation Specialist

Zwarteveen, Margreet — *The Netherlands*
Associate Expert (seconded from the Directorate General International Cooperation (DGIS), Ministry of Foreign Affairs of the Government of the Netherlands)

### International Cooperation Group

Abeywickrema, Nanda — *Sri Lanka*
Director, International Cooperation

de Silva, Dhammika
Senior Secretary

França, Zenete — *Brazil*
Training Specialist (until October)

Mutukumarana, P.
Assistant to the Training Specialist

Ratnayake, Ranjith
Assistant to the Director, International Cooperation

## ANNEX IV *(Continued)*

### Bangladesh

Parker, Donald — *USA*
Head, Bangladesh Field Operations

Hakim, M.A.
Economist

Rahman, Abdur
Administrative Officer

### Burkina Faso

Sally, Hilmy — *Sri Lanka*
Irrigation Specialist and Project Leader

Lingani, Séni
Accountant/Administrative Officer

Pouya, André-Marie
Information and Communications Specialist

### Morocco

Verdier, Jean — *France*
Head, Morocco Field Operations (until May)

### Nepal

Valera, Alfredo — *The Philippines*
Head, Nepal Field Operations

Durga, K.C.
Research Officer (until December)

Gami, Vinay
Research Associate (until October)

Neupane, Nita
Gender Analysis Researcher

Pradhan, T.M.S.
Research Fellow (until June)

Pradhan, Ujjwal — *Nepal*
Assistant Irrigation Specialist

Shrestha, A.
Research Associate

### Niger

Lonsway, Kurt — *USA*
Irrigation Specialist and Project Leader

### Nigeria

Pradhan, Prachanda — *Nepal*
Irrigation Specialist and Project Leader (until December)

Aiyewumi, Felix
Research Assistant

Babura, Alh. Rabiu Abubakar
Research Officer

Miga, Idris
Research Assistant

Omotowoju, Joseph S.
Agriculture Engineer

### Philippines

Manangan, Celso C.
Administrative Officer

Valdez, Ma. Delia M.
Research Assistant

### Sri Lanka

Wijayaratna, Chandrasekera M.— *Sri Lanka*
Head, Sri Lanka Field Operations

Abeyewardene, A.
Research Officer

Aluwihare, Parakrama
Research Officer

Ariyaratne, B.R.
Research Officer

Brewer, Jeffrey — *USA*
Social Scientist

Ekanayake, Ratnasiri
Research Officer

Gamaathige, A.
Research Associate

Haq, K. Azharul— *Bangladesh*
Agricultural Engineer/Technical Advisor for IRMU

Hemakeerthi, K.A.
Agronomist/Research Officer

Jinapala, K.
Research Associate

Karunasena, H.A.
Research Associate (until March)

Maheswaran, Kalaranjani
Agronomist/Research Officer (until September)

Nanayakkara, Chandrasiri
Agricultural Economist/Research Associate

Perera, L.R.
Research Officer

Sakthivadivel, Ramaswamy — *India*
Senior Irrigation Specialist

Samarakoon, Dharshana
Administrative Officer

Somaratne, P.G.
Research Officer

Upasena, W.J.J.
Agricultural Economist/Research Officer

Withana, Chulawansa
Research Officer

## ANNEX IV *(Continued)*

### Shared Control of Natural Resources Project

Adikaramge, N.K.
Enterprise Development/Marketing Specialist (from August)

Batuwitage, G.P.
Monitoring and Evaluation Specialist (from September)

Ekanayake, E.M.A.
Research Officer (from November)

Ekanayake, P.S.B.
Finance Officer (from August)

Fernando, N.
Research Associate (from October)

Jayasuriya, K.N.
Enterprise Development/Marketing Specialist (from September)

Jayawardena, K.
Research Officer/Computer Analyst (from December)

Karunaratne, G.
Watershed Management Coordinator (from September)

Karunaratne, P.G.
Watershed Management Coordinator (from September)

Karunaratne, R.M.
Deputy Team Leader (from September)

Kotuwegedera, J.P.K.
Research Officer (from November)

Kuruppu, W.
Watershed Management Coordinator (from September)

Medagama, J.
Team Leader (from September)

Nanayakkara , V.K.
Team Leader (from September)

Rajasekera, D W.P.
Coordinator, Human Resources (from August)

Samarakoon, Banda, J.M.
Research Associate (from September)

Samaranayake, G.
Administrative Officer (from August)

Sirimal, Bandula R.B.
Research Officer/Agricultural Economist (from December)

Tennakoon, T.M.C.K.
Organizer, Women and Youth Organizations (from September)

Upali Chandra, K.A.
Administrative Officer (from December)

Warnasuriya, T.K.
Deputy Team Leader (from September)

Widanapathirana, A.S.
Research Associate (from October)

Wijenayake, D.
Watershed Management Coordinator (from September)

### Sudan

Shafique, Muhammad S. — *Pakistan*
Senior Irrigation Specialist

Ali Dingle, Mohamed A.
Senior Agricultural Economist

Samuel, R.I.
Accountant (until December)

Tawadrous, M.E.
Agricultural Economist

### PAKISTAN GROUP

Skogerboe, Gaylord V. — *USA*
Director, Pakistan (from August)

Afaq, Rana Mohammad
Irrigation Engineer

Anwar, Haroon
General Manager
Finance and Administration

Babar, Khurshid
Field Research Engineer (until October)

Badruddin, Mohammad
IIMI Pakistan Associate

Bandaragoda, D. Jayatissa — *Sri Lanka*
Senior Management Specialist

Bhatti, M. Akhtar
Principal Irrigation Engineer (until March)

Garces-Restrepo, Carlos — *Colombia*
Irrigation Specialist

Habib, Zaigham
Systems Analyst

Haider, Sayed Daniyal
Accountant

Khan, Hakeem
Field Research Engineer

Kuper, Marcel — *The Netherlands*
Associate Expert

Miranda, Senen — *The Philippines*
Senior Irrigation Specialist (until June)

Rehman, Gauhar
Civil Engineer (GIS Specialist)

Rehman, Saeed-ur
Senior Field Research Economist

Safdar, Ahmed Saleem
Field Research Engineer (until October)

Saleem, Mohammad
Field Research Social Scientist

## ANNEX IV *(Continued)*

Sendu, Faiz Hanif
Senior Field Research Hydrologist (until October)

Shahid, Bagh Ali
Principal Irrigation Engineer (until December)

Shahid, Sarwar
Field Research Hydrologist

Strosser, Pierre — *France*
Agricultural Economist

Van Waijjen, Erik — *The Netherlands*
Associate Expert (until August)

Vander Velde, Edward J. — *USA*
Senior Irrigation Specialist

Zaman, Waheed-uz
Senior Field Research Engineer

### COMMUNICATIONS DIVISION

#### Information Office

Lenahan, James — *United Kingdom*
Head, Information

De Alwis, Manik
Assistant Documentalist (from May)

De Silva, Ramya
Documentalist

Fernando, K. Nimal A.
Manager, Production and Editorial Services

Gunasekera, Manisha
Production Editor (from January)

Jayakody, Kithsiri
Typesetter

Karunaratne, D.C.
Artist/Cartographer

Kurukulasuriya, Kingsley
Production Editor

Nanayakkara, Charith
Computer Services Manager

Nesiah, Vaseeharan
Communications Officer (from September)

Rabindranath, Susila
Press Officer (until January)

Sri-Nammuni, Shanthi
Assistant Librarian

Sufian, A.C.M.
Production Manager

Umagiliya, Nargis
Writer

Van Eyck, David
Distribution Manager

Wickremasinghe, Ranjith
Computer Technician

Yapa, N.U.
Head Librarian

#### Donor Relations and Project Development Office

Fuchs-Carsch, Marian — *USA*
Project Development Officer

Blok, Sharmini
Assistant Project Development Officer

Dhanapala, Kiran
Project Development Associate (from August)

### FINANCE AND ADMINISTRATION DIVISION

Andrews, Nancy — *USA*
Director, Finance and Administration (from January)

Abayasekera, Mohan
Manager, Travel and Conferences

Abeysekera, Laksiri
Controller

Abeyesekera, Fred
Personnel Manager (until June)

Amarasuriya, Sepala
Senior Manager, Human Resources (from October)

Bahar, Omar
Personnel Officer

Buultjens, Rodney
Office Equipment Technician

Ekanayake, Somasiri
Assistant Accountant (until July)

Halvitige, Gamini
Senior Accountant

Perera, K.S.C.
Maintenance Engineer (until October)

Samarakoon, Ranjith
Assistant Accountant (from September)

Samaraweera, Daya
Manager, Administrative Services

Vander Say, Avril
Senior Secretary

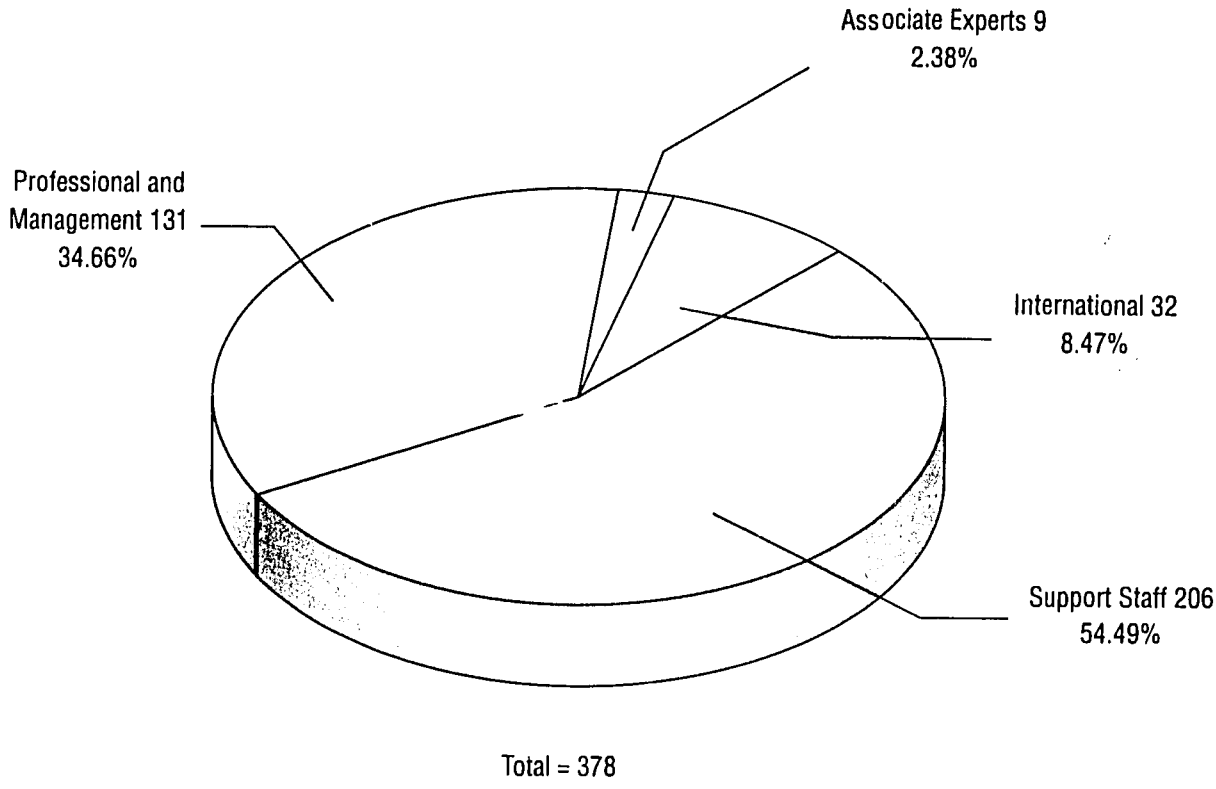
Weerasekera, Shanthi
Manager, Office Support Systems

Wettasinghe, Udaya
Manager, Budget Office

[1]Based at IFPRI, under IIMI-IFPRI Collaborative Program.

[2]Based at IPTRID (on secondment from IIMI).

*Figure 14. Composition of IIMI Staff.*



# ANNEX V
# CONSULTANTS 1993

| Name | Country in which the Consultancy was Conducted | Mission |
|---|---|---|
| | | **Programs Division** |
| M.D.C. Abayaratna | Sri Lanka | To edit FMIS Groundwater Workshop papers. |
| K. Athukorale | Sri Lanka | To work on research activities in Sri Lanka for the Gender Program. |
| D. Constable | Sudan | To conduct workshop as part of IIMI team to deliver results of TNA held in Sudan. |
| J. Fernandez | U.S.A. | Study of irrigation management transfer in Colombia. |
| L.D. Jones | Australia | To review the procedures for evaluating irrigation performance currently in use in Australia. |
| G. Levine | Mexico and Nepal | To assist IIMI to initiate its research program in Mexico with two collaborating institutions and to review IIMI's collaborative programs in Nepal. |
| M. Pikeris | Argentina | To translate the text of the IIMI Review and FMIS Newsletter. |
| D. Purkey | USA | To report on "Current Practices and Procedures of Irrigation Performance Assessment in California". |
| S.K. Raheja | India | To prepare a paper on "Methodologies for Field-Testing of Performance Indicators of Irrigated Agriculture". |
| S.K. Raheja | Sri Lanka | To assist IIMI staff in the methodological aspects of quantifying linkages between management interventions and performance indicators of irrigated agriculture: A Case Study of Muda Irrigation System in Malaysia. |
| R. Rangachari | India | To prepare a review report on "Existing Procedures and Practices of Irrigation Performance Assessment in India". |
| P.S. Rao | India | To prepare a paper on "Current Procedures and Practices for Assessing Performance of Irrigated Agriculture: A Synthesis Report of Reviews from Industrialized and Developing Countries". |
| P.S. Rao | Sudan, Bangladesh, Sri Lanka, and Malaysia | To review plans for training activities in Sri Lanka. To review report on TNA in Sudan. To discuss the development of activities at DID, Malaysia. To discuss the development of activities in BADC, Bangladesh and to collect further information on the Corporation to prepare a comparative study of the irrigation organizations in three different countries. |

## ANNEX V *(Continued)*

| Name | Country in which the Consultancy was Conducted | Mission |
|---|---|---|
| S. Rozelle | China | To work on a case study on irrigation management transfer in China. |
| D. Walton | Sri Lanka | To review IIMI's Strategy and MTP in detail. |
| M. Yudelman | Sri Lanka | To discuss the paper on "Demand and Supply of foodstuffs upto 2050 with Special Reference to Irrigation". |

### International Cooperation Group

| | | |
|---|---|---|
| R.S. Abeysekera | Sri Lanka | To carry out study on projects related to crops and crop production in the Nilwala Watershed where the SCOR Project has commenced field activities relating to natural resource management. |
| O. Amarasinghe | Sri Lanka | To study crop production and livestock components of the KOISP Impact Assessment Study. |
| M.A.B. Anawaratna | Sri Lanka | To analyze demand, supply and price of tomato and onion production in Sri Lanka with special reference to irrigation and production scheduling. |
| J. Beekma | Pakistan | To help review data collection on irrigation practices and soil salinity and to provide insights on the role of soil properties in salinization/sodication processes. |
| J.C. Legoupil | West Africa | To be responsible for implementation of IIMI's program in the regional office in Ouagadougou. |
| N. Neupane | Nepal | To conduct a study on gender issues in irrigation at Chhattis Mauja Irrigation System. |
| C.R. Panabokke | Sri Lanka | To act as secretary of the Sri Lanka-IIMI Consultative Committee, and to contribute to the project on Irrigation Management and Crop Diversification. |
| S. Rabindranath | Sri Lanka | To edit report on "The Dynamics of Irrigation Systems Performance". |
| P. Rajasekera | Sri Lanka | To visit Huruluwewa and Nilwala watersheds to identify and assist in selecting suitable office/residential accommodation for staff of SCOR and help SLFO develop SCOR Project Proposal. |
| K.V. Raju | India and Sri Lanka | To assist senior researchers of both IIMI and IIMA in undertaking the India Turnover Study and completion of manuscript for Bihar groundwater study. |

## ANNEX V *(Continued)*

| Name | Country in which the Consultancy was Conducted | Mission |
|---|---|---|
| S.Z. Sadeque | Bangladesh | To work with IIMI/ Bangladesh on inception activities shaping the study of Minor Irrigation Privatization. |
| M. Schaap | Niger | To complete a Gender Relations Study on the Tillakaina and Saga perimeters. |
| F.E. Schulze | West Africa | To act as IIMI's Regional Representative for West Africa. |
| G. Shivakoti | Nepal | To conduct a study on the support services for farmer-managed irrigation systems. |
| J.C. van Dam | Pakistan | To test the utility of the simulation of water and solute transport, using an agro-hydrological model for the analysis of irrigation-induced salinization processes. |
| A. Weerasinghe | Sri Lanka | To identify and measure KOISP output and trends. |
| M. Wijeratna | Sri Lanka | To study crop production and livestock components of the KOISP Impact Assessment Study. |

### Information Office

| | | |
|---|---|---|
| S. Chater | Sri Lanka | To write Annual report 1993. |
| M.P. Fernando | Sri Lanka | To translate Burkina Faso Evaluation Project Report. |
| G. Fouquet | Thailand | To translate an agreement from French to English. |
| S. Meegama | Sri Lanka | To typeset IIMI publications in English, Spanish and French. |

### Other Offices

| | | |
|---|---|---|
| W. Daudrumez | Sri Lanka | To work as the International Recruitment Consultant. |
| E. de Silva | Sri Lanka | To work as the Transportation Consultant. |
| E. Dina | Sri Lanka | To translate into Spanish the document on Approach to Irrigation Management. |
| S. Fernando | Sri Lanka | To beautify the headquarters building. |
| P. Kokuleraj | Sri Lanka | To review the headquarters building partitioning options. |
| C. Watson | Sri Lanka | To develop proposed framework for the organization of the General Administrative Practices Manual. |

## ACRONYMS AND SYMBOLS

| | |
|---|---|
| ADB | Asian Development Bank |
| AFDB | African Development Bank |
| AIT | Asian Institute of Technology (Bangkok) |
| BADC | Bangladesh Agricultural Development Corporation |
| BAU | Bangladesh Agricultural University |
| BMZ | Bundesministerium für Wirtshaftliche Zusammenarbeit (Germany) |
| CADSWES | Center for Advanced Decision Support for Water and Environmental Systems |
| CEMAGREF | Centre National du Machinisme Agricole, du Génie Rural, des Eaux et des Forêts (France) |
| CEWRE | Center of Excellence in Water Resources Engineering |
| CGIAR | Consultative Group on International Agricultural Research |
| CIDA | Canadian International Development Agency |
| DANIDA | Danish International Development Association |
| DID | Department of Irrigation and Drainage (Malaysia) |
| DSE | Deutsche Stiftung für Internationale Entwicklung (Germany) |
| EC | Commission of the European Communities |
| ETSHER | Ecole Inter-Etats des Techniciens Supérieurs de l'Hydraulique et de l'Equipement Rural (Burkina Faso) |
| FAO | Food and Agriculture Organization of the United Nations |
| FMIS | Farmer-Managed Irrigation Systems |
| HJRBDA | Hadejia Jama'ara River Basin Development Authority (Nigeria) |
| IAAS | Institute of Agriculture and Animal Science (Nepal) |
| IASCP | International Association for the Study of Common Property |
| ICID | International Commission on Irrigation and Drainage |
| IFAD | International Fund for Agricultural Development |
| IFPRI | International Food Policy Research Institute |
| IHE | International Institute for Infrastructural, Hydraulic and Environmental Engineering |
| IIMA | Indian Institute of Management |
| ILO | International Labour Organisation |
| ILRI | International Institute for Land Reclamation and Improvement |
| IMTA | Instituto Mexicano de Tecnologia del Agua |
| IPTRID | International Program for Technology Research in Irrigation and Drainage |
| IRMU | Irrigation Research Management Unit (Sri Lanka) |
| ISMP | Irrigation Systems Management Project |

## ACRONYMS AND SYMBOLS *(Continued)*

| | |
|---|---|
| IUCN | World Conservation Union |
| IWASRI | International Waterlogging and Salinity Research Institute |
| IWRA | International Water Resources Association |
| JIRCAS | Japan International Research Center for Agricultural Sciences |
| KOISP | Kirindi Oya Irrigation and Settlement Project (Sri Lanka) |
| MTP | Medium-Term Plan |
| NGOs | Nongovernmental Organizations |
| NIA | National Irrigation Administration (The Philippines) |
| NIRP | National Irrigation Research Project (Sri Lanka) |
| ODA | Overseas Development Administration (UK) |
| SCOR | Shared Control of Natural Resources (Sri Lanka) |
| SIDA | Swedish International Development Authority |
| SLFO | Sri Lanka Field Operations |
| TA | Technical Assistance |
| TAC | Technical Advisory Committee of the CGIAR |
| TNA | Training Needs and Organizational Constraints Assessment |
| UNDP | United Nations Development Programme |
| USAID | United States Agency for International Development |
| WARDA | West Africa Rice Development Association |

# IIMI ADDRESSES

## HEADQUARTERS

127, Sunil Mawatha,
Pelawatte via Colombo
Sri Lanka

Telephone : (94-1) 867404 (8 lines)
Telex : 22318 or 22907 IIMIHQ CE
Fax : (94-1) 866854
E-Mail : CGNET:IIMI (157:CGI 129) or Internet:IIMI @CGNET.COM
P O Box : PO Box 2075, Colombo, Sri Lanka

## BANGLADESH

IIMI, Bangladesh Field Operations
56A, Road 16 (New)
Dhanmandi R.A.
Dhaka 1209
Bangladesh

Telephone : (880-2) 324128
Telex : 642940 ADAB BJ (Attn:IIMI)
Fax : (880-2) 813095 (Attn:IIMI)
E-Mail : D.PARKER-FORD

## MOROCCO

IIMI, Morocco Field Operations
c/o SEHA
461, Avenue Hassan II
Al Akkari
Rabat
Morocco

Telephone : (212 -7) 691101
Telex : MARDER 36705M (Quote "IIMI")
Fax : (212-7) 691101 or thro' Backup Services, 44-491-832002 or thro' IIMI-Pakistan, 92-42-6369194
E-Mail : IIMI-RABAT (157:CGI064)

## NEPAL

IIMI, Nepal Field Operations
P O Box 3975
Kathmandu
Nepal

Telephone : 977-1-414376 or 411912 (Ext.18)
Telex : 2321 BASS NP (Attn:IIMI) Alt & Saturdays: 2660 GURANS NP
Fax : 977-1-415535 Alt. (977-1) 521880 (Attn. IIMI)
E-Mail : IIMI-Nepal (157:CGI106)

## PAKISTAN

IIMI, Pakistan Division
1 A/B Danepur Road
GOR 1, Lahore
Pakistan

Telephone : (94-42) 6368610, 303251
Telex : 44926 IIMI PK
Fax : (94-42) 6369194
E-Mail : IIMI-PAK (157:CGI220)

## PHILIPPINES

IIMI, Philippines Field Operations
2nd Floor, ICC Bldg.
NIA Compound, EDSA
Diliman, Quezon City
Metro Manila
Philippines

Telephone : (63-2) 9242567
Telex : 40404 GMCR (Attn:IIMI)
Fax : (63-2) 9242567

## SRI LANKA

IIMI, Sri Lanka Field Operations
107, Havelock Road,
Colombo 5

Telephone : (94-1) 508001/7
Telex : 22318 or 22907 IIMIHQ CE
Fax : (94-1) 508008

## SUDAN

IIMI, Sudan Field Operations
P O Box 318, Wad Medeni

Telephone : 3148 (Gezira System)
Telex : 50013 HRS SD or 50009 TXBOWD SD (c/o Mr.Monshid, HRS)

IIMI, Sudan Field Operations
Liaison Office
St. 53 New Extension, House 9/11
P O Box 2976, Khartoum, Sudan

Telephone : (249-11) 451504
Telex : 24033 KENAN SD 22554 AOAD SD (Attn.IIMI)
Fax : (249-11) 451643

## WEST AFRICA REGIONAL OFFICE

IIMI, West Africa Regional Office
IIMI BP 5373, Ouagadougou 01
Burkina Faso

Telephone : (226) 308489
Telex : 5381 SAFGRAD BF (Attn:IIMI)
Fax : (226) 31-06-18
E-Mail : IIMI-BURKINA (157:CGI195)

## NIGER

IIMI BP 10883, Niamey, Niger

Telephone : (227) 73-29-58
Telex : 5463 NI (Attn: Kurt Lonsway)
Fax : (227) 73-59-83
E-Mail : IIMI-NIGER (157:CGI058)

## NIGERIA

Hadejia Jama'ara River Basin
Development Authority
Authority Headquarters
Maiduguri Road
PMB 3168
Kano, Nigeria

Telephone : 064-648237 Ext. 55
Fax : 064-648184