ANNUAL REPORT 1994

International Irrigation Management Institute

Contents

Foreword

In December 1994, as my tenure as IIMI's Director General drew to a close, the Institute celebrated its tenth anniversary. At a simple ceremony held in Colombo attended by IIMI's Board and staff and many friends of the Institute, Anuruddha Ratwatte, Sri Lanka's Minister for Irrigation, Power and Energy, paid tribute to IIMI's assistance in bringing about management and policy changes in its host country. The Minister's remarks, together with the stirring keynote address on *Trends in International Agricultural Research: Crises and Challenges* by Michel Petit, Director for International Agricultural Research at the World Bank, provided the opportunity for all those present to reflect on the way in which irrigation research and development have evolved over the last decade—and on the special contributions that IIMI has made to this rapidly developing field.

On the policy and management front, much has changed in the 10 years since IIMI was created. The Institute's establishment came towards the end of a period in which the focus of attention in irrigation was invariably investment in new infrastructure. Looking back on IIMI's early days, it seems strange to recall how difficult it was at that time to explain its mandate and justify its existence. Today, in contrast, the case for better irrigation management and policymaking no longer needs to be made. The quest for greater efficiency in the use of irrigation water has risen to the top of the political agenda in virtually every developing country with a significant irrigation sector.

Greater awareness of the need for improvement is one measure of the progress made by IIMI and its partners, but awareness must be accompanied by research-based knowledge and information. Today, as at its foundation, IIMI's task is to help policymakers and managers have the knowledge base needed to identify and implement practical measures to increase irrigation performance. These measures apply both to the development and introduction of new management systems and technologies at the irrigation system level, and the broader array of institutional and policy reforms at the sectoral level. Experience has shown that managerial and technological innovations are seldom effective if introduced in isolation. They depend for their success on the conducive conditions created through institutional and policy changes.

This 1994 Annual Report provides ample evidence that IIMI is performing its task at both these levels. In addition to its in-depth studies on individual irrigation systems, the Institute has been conducting a continuing dialogue with policymakers and senior managers in most of the countries in which it operates. To achieve a multiplier effect from its work in specific countries, it has also compared experiences across countries, drawing out the lessons for a wider audience. Let me touch on a few key events in 1994 that illustrate this process at work.

Over the past decade, IIMI has worked steadily with its partners on the development and introduction of computer-based tools to aid decision making in operations and maintenance—a fast-moving field in which technological change has opened up considerable opportunities for improving day-to-day management in individual irrigation systems. In 1994, thanks to the enthusiasm of national institutions and system managers in the Gujarat State of India, we completed the testing of a new data collection and information management system for the large-scale Mahi Kadana Scheme. So successful was this pilot-testing phase that the Scheme's managers have had no hesitation in extending the use of the package throughout the Scheme's 212,000-hectare command area. Trial introductions are now being made on other large-scale schemes in the State.

The Mahi Kadana experience forms the subject of a short article in the first issue of a new newsletter produced and disseminated by IIMI in 1994. The newsletter is the main vehicle for the exchange of information among participants in the network on Information Techniques for Irrigation Systems (ITIS). Jointly sponsored by IIMI and France's Centre National du Machinisme Agricole, du Génie Rural, des Eaux et des Forêts (CEMAGREF), the network aims to link tool users with each other and with tool designers, so as to promote the development and transfer of successful innovations.

Turning to the sectoral level, we find that many countries are currently engaged in a process of radical reform of their irrigation policies and institutions. Central to this process is the turnover of responsibility for irrigation operations and maintenance to farmers. This is often accompanied by sweeping cuts in public spending on irrigation agencies, which must either become financially autonomous or perish.

In the global research community, the subject of irrigation management turnover is now increasingly regarded as an area in which IIMI has a special expertise—one well suited to the kind of cross-country comparison and synthesis at which the international agricultural research centers traditionally excel. Through networking, IIMI and its partners have been able to make a strong contribution to the global stock of knowledge on this topic. We have now provided advice and exchanged information on turnover with policymakers and managers in more than 20 countries. In 1994, we began research programs in Mexico, the country with the world's largest and most ambitious turnover program. And also in 1994 we organized, in collaboration with the Wuhan University of Hydraulic and Electrical Engineering in China, the world's most significant international conference on management turnover to this date. This Tenth Anniversary Conference was attended by over 200 specialists from across the globe, many of whom expressed their admiration for the high quality of IIMI's research in the field.

During the year, IIMI continued to make progress in developing its research program along lines appropriate for a center belonging to the international system of the Consultative Group on International Agricultural Research (CGIAR), which IIMI joined in 1991. The transition to full membership of the CGIAR System has been more difficult than originally envisaged, not least because it has coincided with a sharp cutback in funding. Nevertheless, IIMI now has strong links with several other members of the CGIAR System, with whom it is in the process of defining common research interests. In 1994, the Group's Technical Advisory Committee (TAC) designated IIMI as the "convening center" of an inter-center initiative on water management research. Provided the "transaction costs" can be kept suitably low, IIMI welcomes this opportunity to devise new research partnerships that will enhance the quality and impact of its work. Particularly valuable to IIMI will be its increased access to the expertise of its sister centers in the field of irrigated agriculture. The broadening of the Institute's mandate from irrigation systems to irrigated agriculture was perhaps the most significant change occasioned by IIMI's joining the CGIAR System, and many of the studies summarized in this year's report analyze the complex relationships between water delivery performance and farmers' crop production and incomes—suggesting that the change is already starting to bear fruit.

This is the last IIMI Annual Report that will go out under my signature. It reflects a strong program focused on a key challenge confronting agricultural research and development in the twenty-first century: how to make more efficient use of an increasingly scarce resource. I wish my successor every good fortune in carrying that program forward. And I would like to thank the Board and staff of IIMI, its donors, partners and other stakeholders, for their part in developing the program. It is a pleasure and a privilege to have worked with this wide community of IIMI's friends, and to have served IIMI's noble purpose.

Roberto L. Lenton

Roberto Lenton
Director General

IIMI's Research Results 1994

Reflecting IIMI's progress in developing an integrated research program in partnership with national institutions, we report our research this year in a single thematic section, omitting the country-by-country accounts given in previous years. While this entails some loss of "visibility" for national projects and concerns, we have taken care to give credit to our national partners wherever this is due.

Our four major research themes remain the same as last year—namely, Performance Assessment and Improvement, Water Delivery and Disposal, Public Organizations and Policies, and Local Management. For presentation purposes, we have made minor changes to their wording and sequence.

Besides these programmatic themes, IIMI has three further themes that cut across program boundaries. These are Gender Issues, Environment and Human Health, and Technology. Only one of these, Gender Issues, has its own heading in this report, since it alone has a full-time staff member assigned to it. This crosscutting theme has its intellectual "home" in the Local Management Program. Work on the two other crosscutting themes will be found under various headings throughout the research section of this report.

As in previous years, this year's report presents a selection of the results achieved during the year. More complete accounts are given in the many papers published by IIMI and national scientists in 1994. These are listed in Annex II.

Theme 1 Performance Assessment and Improvement

INTRODUCTION

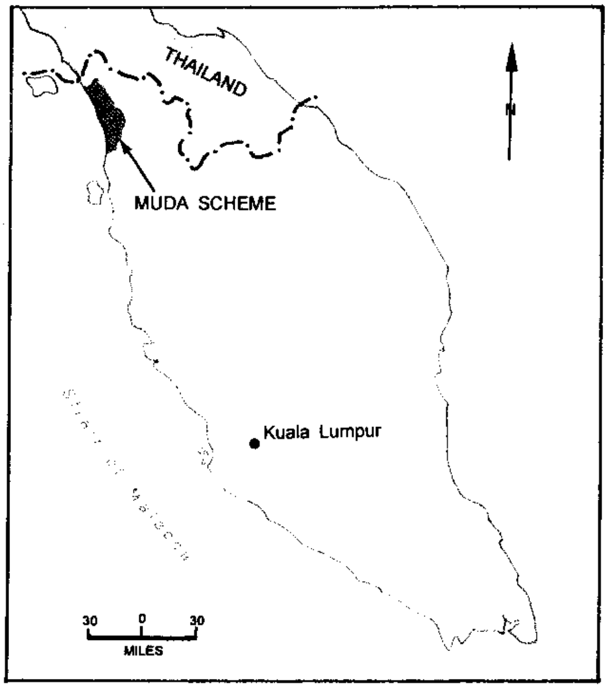
Assessing and improving irrigation performance are central to all IIMI's research—so central as to amount to little less than a statement of the Institute's mandate. Nevertheless, in 1990, IIMI's Board of Governors and senior management staff decided to launch a distinct program on this theme. The main reason for doing so was the need to concentrate resources on the development of methods for assessing performance. Much work had been done on this in the past, but there was a need for further conceptual advances and a synthesis of findings.

There is a continuing need to test assessment criteria and methods in the field, partly to confirm their appropriateness and partly to adapt them to local conditions. In addition, applied research to introduce management technology that will improve performance remains a major program activity, carried out in partnership both with other IIMI programs and with national institutions. For this reason, we retain the heading Performance Assessment and Improvement.

Our selection of case studies this year explores what happens to the performance of irrigated agriculture under different conditions of water supply and demand. Changes in the supply and demand equation may radically affect the outcome of attempts to improve performance—but not always in easily predictable ways. Reduced supplies often lead to reduced crop production—but not invariably. Similarly, a new abundance of canal water may or may not lead to the gains in production anticipated by planners. Even if it does, that is unlikely to mean that water is being used more efficiently.

IIMI's 1993 Annual Report featured a detailed account of events in the troubled Kirindi Oya Scheme of Sri Lanka, as its embattled farmers and managers tried to come to terms with a chronic shortage of water. We begin this year's report by looking at another scheme that faces declining water availability, but which has found answers to the problem: the Muda Irrigation Scheme in Malaysia. Next we turn to Pakistan's North-West Frontier Province, where the remodeling of the Chasma Right Bank Canal provides a rare opportunity to study the behavior of farmers "before" and "after" agency intervention to increase supplies. Thence to Gujarat State in India, where the performance of a large-scale scheme with an undoubted impact on agricultural production looks less impressive when efficiency considerations are taken into account. Last, we explore the delicate trade-off between the adequacy and the reliability of canal water supplies, reporting on work in the Fordwah System of Pakistan's Punjab.

Figure 1. The Muda Irrigation Scheme, Malaysia.



WHAT HAPPENS WHEN SUPPLIES DECREASE? MUDA IRRIGATION SCHEME, MALAYSIA

Over the past decade, Malaysia's Muda Irrigation Scheme (Figure 1) has recorded substantial gains in crop production while experiencing a growing water shortage (see Box). In a joint study with the Muda Agricultural Development Agency (MADA), IIMI's scientists set out to identify the factors underlying this achievement.

MORE FOOD FROM LESS WATER

Malaysia's rice imports have doubled in the past 10 years, as domestic production has slumped. In 1990, they reached 0.33 million tonnes (mt), about a quarter of its total consumption. In the same year, the Muda Irrigation Scheme produced 0.76 mt of rice—nearly half the nation's total production of 1.65 mt.

Encompassing some 96,000 hectares (ha) of rice fields, the Muda Irrigation Scheme is the largest of Malaysia's eight designated "granary" areas. As such it is vital to national food supplies. Under MADA's management, production on the Scheme has bucked the declining national trend, rising from 0.73 mt in 1981 to 0.80 mt in 1991. Average yields, at nearly 8.5 t/ha, are a clear 2 t/ha higher than on the country's other large-scale schemes. Muda's contribution to national food self-sufficiency has increased from 26 percent in 1981 to 50 percent in 1990.

These impressive gains have been made against a background of steadily declining average annual rainfall and increasing demand for water for industrial and domestic uses. Rainfall in 1990–92 was 20 percent less than in 1980–82, and dam releases were 15 percent lower. Industrial and domestic demands, which now account for 11 percent of Muda's supplies, are forecast to double by the year 2000. If new sources of water are not found, irrigation supplies to farmers will have to be further reduced by around 15 percent over the nexp 5 years.

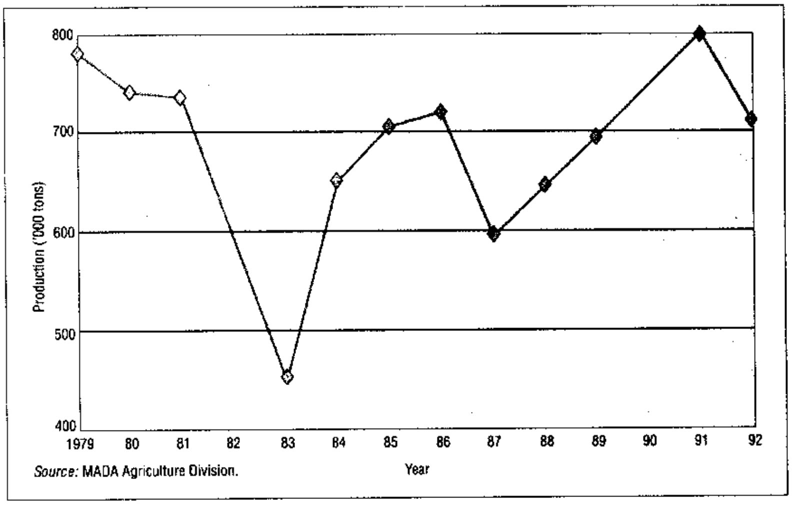
A more detailed analysis of Muda's performance over time reveals an intriguing picture (Figure 2). Production and yields actually fell between 1979 and 1983, but picked up again swiftly thereafter. In other words, the Scheme has succeeded not only in arresting a declining trend but in sending it sharply into reverse. When the fluctuations are ironed out, average output shows an increase of around 16 percent over the past decade. During the same period, output per cubic meter (m^3) of water rose by an impressive 45 percent, while the productivity of labor increased by one-third.

What was special about the mid-1980s that enabled the Muda Irrigation Scheme to transcend the limitations imposed by steadily declining water availability? Below is a chronology of the Scheme's development over the past 25 years:

1966 Construction of Muda I Project begins

1970 Muda Agricultural Development Agency set up
Double-cropping of rice starts
Plowing mechanized

Figure 2. Annual rough rice production in Malaysia's Muda Irrigation Scheme, 1979–1992.



1972 Early-maturing rice varieties introduced

1975 Double-cropping of rice extended throughout the scheme

1977 Tertiary Development Project launched (Muda II)

1978 Fertilizer subsidy introduced

1980 Rice subsidy introduced
Direct sowing introduced

1982 Group farming organized

1984 Muda II comes on-stream
Water cutoff date introduced

1985 Mechanized harvesting extended to the whole Muda Irrigation Scheme

1986 Direct sowing covers 50 percent of the cultivated area

1988 Performance data computerized

1989 Data feedback system fully functional

1992 Scheduling based on dry sowing introduced

Water shortage has been the most significant constraint to production since 1975, when double-cropping was introduced throughout the scheme. Since then, both the agency and the farmers have looked for ways of saving water and using it more efficiently. Some of the measures taken have been agronomic—the introduction of mechanized harvesting and a switch to direct sowing. But the Scheme has also undergone substantial infrastructural development and a series of management interventions. These efforts have baen supported by several policy measures introduced at national level, including subsidized fertilizer and rice prices.

AGENCY INTERVENTIONS

Tertiary Development

Consisting of the construction of field canals and farm roads, the Scheme's development at tertiary level, known as the Muda II Project, was planned and implemented by MADA starting in 1977. Progress was slow to begin with, and the first 2,000 ha became operational only in 1984. The pace then quickened, with the area covered rising to 23,639 ha by 1992.

Intensifying the network of field canals brings water closer to the farmer, allowing improved control at field level. Each plot can be watered simultaneously from its own outlet, rather than sequentially from a single outlet. As a result, water is spread more evenly and its depth is more uniform across fields, reducing distribution losses. Water can also be directed separately to nursery beds and main fields. This means that the latter need no longer be flooded throughout the 25-day period for which seedlings remain in the nursery, while the former need not continue to be inundated after transplanting. Combined with dry sowing (see Box, p.5), tertiary development has led to an estimated water saving of about 3,200 m^3/ha/year—some 20 percent of the total supply for irrigation.

The construction of farm roads reduces the costs of delivering inputs and transporting harvests to the market.

Most indicators of Muda's performance show marked improvements after tertiary development, suggesting that it was highly effective in arresting and reversing the Scheme's decline.

Duration of Irrigation Period

The length of the irrigation period has a considerable impact on the amount of water used and hence on the efficiency of water use. A reduction of only 5 days leads to an estimated water saving of 794 m^3/ha/year. Since 1984, MADA has been able to shorten the irrigation period from 197 to 152 days. The principal management intervention used was the water cutoff date (see Box, p.4).

SCARCITY AND EQUITY: THE WATER CUTOFF DATE

The idea of setting a date on which canal water supplies would cease was to compel farmers to begin their cropping operations promptly and compress them into as short a period as possible, avoiding overambitious schedules.

First introduced on a trial basis in 1984, the water cutoff date was announced to farmers at the start of each season from 1986 onwards. Farmers resented the practice at first, but gradually came to accept it as a necessary evil. Provided the date was known well in advance, only a few poor planners or "unbelievers" were caught out by terminal drought—and the number steadily reduced each year as farmers saw that the agency meant what it said. The effectiveness of the cutoff date is reflected in the average latest date on which farmers harvest their second crop, which has been brought forward by 32 days since 1984. The chief saving is in the turnaround between the first and second seasons.

The use of the cutoff date in Malaysia forms a marked contrast with practices in some areas of Sri Lanka, where water scarcity is commonly dealt with by depriving some farmers of water altogether (see IIMI Annual Report 1993, pp. 1–6). The Malaysian method is, at the same time, more equitable and more liberal—treating all farmers the same but leaving them free to decide how to respond in terms of selecting a suitable cropping strategy.

If applied firmly or fairly, the water cutoff date can be highly effective. It is a low-cost intervention that deserves more widespread testing and use, especially in rice-based irrigation schemes.

By shortening the irrigation period, the agency speeded up the adoption of direct sowing and, to a lesser extent, early-maturing crop varieties (see pp. 5 and 6).

Data Feedback System

In 1988, MADA installed a sophisticated data feedback system geared to increasing water use efficiency. The system consists of 25 telemetric monitoring stations and 27 VHF stations linked via a local area network (LAN) to a mainframe computer at MADA headquarters. It enables water depth to be measured daily at five locations in each of the Scheme's 110 irrigation blocks. The aim is to increase the speed and flexibility of operational responses to changes in rainfall, dam inflow, stream and river flow, water depth in farmers' fields and other variables.

The new system has reduced the time-lag between data collection and the alteration of discharge rates to one day. MADA staff say it has helped them maximize the use of rainfall for rice production, with corresponding savings in canal water. Credibility with farmers has also improved, increasing their cooperation with agency staff.

Recycling of Drainage Water

Declining rainfall prompted MADA to install pumping stations to recycle some of the Scheme's drainage water. Between 1984 and 1993 some 10 stations were opened, with a total pumping capacity of 22.4 m^3/sec. This is sufficient to recycle about 14 percent of the total amount of drainage water available. Further increasing this percentage will be critical in making up future water deficits.

Organization of Farmers

Starting in 1982, MADA organized the Scheme's farmers into groups called *kelompoks*. These in turn may evolve into mini-estates—an advanced stage of group farming in which farmers share the tasks of plowing, planting, irrigating and harvesting. There are now about 90 mini-estates in the Muda command area.

Mini-estates are eligible for a government subsidy of RM 1,000 (US$370) per ha to improve infrastructure (farm roads and feeder channels), a further loan of RM 1,000 for use in tractor plowing and the purchase of other inputs, and subsidies for the installation of pumping equipment.

Group farming is thought to have increased yields by lowering the costs of mechanized operations. Where pumps have been installed, it may also have brought savings in the use of canal water.

FARMERS' RESPONSES

Direct Sowing

Encouraged by MADA, farmers responded to labor and water shortages by adopting direct sowing (see Box). The spread of direct sowing was strongly associated with tertiary development and the introduction of a water cutoff date. It was a major factor enabling the agency to reduce the length of the irrigation period.

Direct sowing at Muda is estimated to have reduced labor costs by 30 percent and overall production costs by 40 percent.

PLANTING METHODS AT MUDA

Farmers at Muda can choose among three different methods of planting rice: *transplanting, wet sowing* and *dry sowing*. The latter two methods constitute direct sowing. The amount of water required for each method differs greatly, but so also do crop yields, labor inputs and overall profitability.

Transplanting is the traditional method. Production is high and stable, but costly in terms of both labor and water use. As Malaysia's economy has grown, the rising demand for labor has forced up wages in the agriculture sector, causing a sharp increase in the costs of transplanting. This has driven farmers to switch to the other two methods. Nowadays transplanting is mainly used only in poorly drained areas with deep water, which are not suitable for direct sowing.

In the *wet sowing* method, fields are presaturated, puddled, leveled and then drained, before the pre-germinated seed is broadcast. The growing period in the field is about 10 days longer than in the transplanting method, in which seedlings are first raised in the nursery for around 25 days. Wet sowing therefore has the highest demand for water of all three methods. However, it also reduces labor costs and so increases farmers' profits. Wet sowing is now the method most commonly used by farmers for the second cropping season. In recent years, it has covered more than 80 percent of the Scheme's cultivated area.

Dry sowing is a response to water shortage. In this method, seeds are plowed into the soil before the onset of the rains. Irrigation water is provided only when rainfall has stimulated germination and the seedlings have established. Because pre-saturation is avoided and the irrigation period is shortened, this method sharply reduces the consumption of water (by about 28 percent). However, it also lowers yields (by about 10 percent), due mainly to the intrusion of weeds and to uneven germination. In recent years, dry sowing has been adopted by farmers at Muda over about 70 percent of the area cultivated during the first cropping season. (It cannot be used for the second season, since fields are already flooded.)

Of the three methods, wet sowing is the one preferred by farmers, because of its high yield and low production costs. But because the agency controls the water resource, it has been able to impose a switch to dry sowing despite farmers' dislike for this method.

Early-Maturing Varieties

Planting early-maturing varieties of rice brings gains in both yields and yield stability. By reducing evapotranspiration and the length of the growing period, it also saves water.

According to national researchers, relatively few farmers at Muda have adopted the earliest-maturing varieties now available. Their favorite variety remains the 132-day MR84, released in 1985. This has a yield potential of 6.8 t/ha and is planted over 75 percent of the cultivated area. If farmers were to switch to a 125-day variety, the irrigation period could be shortened by a further 5 days.

However, farmers use many other criteria besides the length of the growing period in choosing their crop varieties. It will be up to researchers to combine early maturity with other desirable traits, including pest and disease resistance, to promote more widespread adoption.

POLICY ENVIRONMENT

The increased productivity of the Muda Irrigation Scheme is partly due to a conducive policy environment. In 1979, the government introduced the provision of free fertilizers to farmers for areas of up to 2.4 ha—a subsidy worth around US$46 per ha at 1991 prices. This measure was closely followed by the introduction of a guaranteed minimum price for unhusked rice. The direct subsidy element of this price was estimated at RM 248 (US$92) per tonne in 1991.

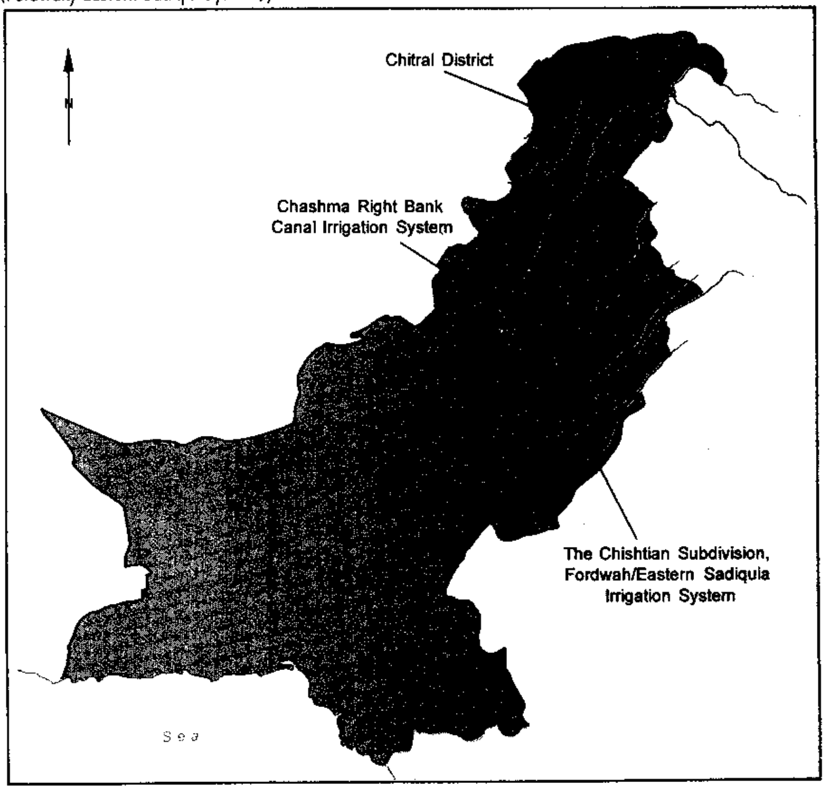
These policy measures did not by themselves increase production, which continued to decline until 1983 at Muda, and for longer elsewhere. However, they provided farmers with the incentive to produce more once the other necessary conditions for higher output were in place.

Input deliveries and infrastructural development were assisted through the introduction of group farming in 1982. Other forms of institutional support were provided through the Federal Agricultural Marketing Authority, the Malaysian Agricultural Research and Development Institute and the National Paddy and Rice Authority.

CONCLUSIONS

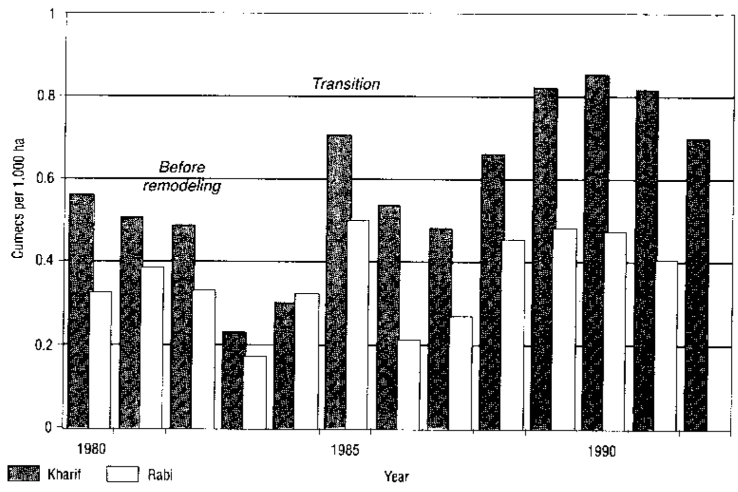
The Muda Irrigation Scheme is a Malaysian success story. It provides heartening evidence that, if adequate measures are taken to improve water use efficiency, high yields and cropping intensities can be achieved and sustained over time, even when water is scarce.

Figure 3. The Chitral District, the Chasma Right Bank Canal Irrigation System and the Chishtian Subdivision (Fordwah/Eastern Sadiqia System), Pakistan.



No single factor or group is responsible for Muda's success. Agency officials, farmers and government policymakers have all played their part. In so doing they have set an example that other irrigation systems facing similar water shortages would do well to emulate.

Figure 4. Canal water supplies at the head of Girsal Minor, 1980–1992.



WHAT HAPPENS WHEN SUPPLIES INCREASE? CHASMA RIGHT BANK CANAL, PAKISTAN

The Chasma Right Bank Canal Irrigation System (Figure 3), in Pakistan's North-West Frontier Province, is one of the country's newest large-scale irrigation systems. The first 32 km of the canal became operational in 1986; the remaining 253 km are still under construction. The new system is designed to deliver water at 0.6 liter per second per hectare (l/s/ha), a rate twice that of the province's older systems.

The new system "swallows" an older one, the Paharpur Canal System, which was remodeled between 1983 and 1985 to cope with the extra water supplies.

The remodeling provided a valuable opportunity to find out how farmers would respond to increased water supplies. Would they expand the area cropped, or increase the number of crops grown in a year? How would cropping patterns be affected? Would yields increase? And would water be used more or less efficiently?

To answer these questions, IIMI launched a study on the Girsal Minor Canal, in the old Paharpur Canal System. Data were collected through interviews with 50 farmers in 4 sample watercourses in 1991 and 1992. The Provincial Irrigation Department and the Provincial Agriculture Department provided supplementary data.

The farmers of Paharpur have had long experience with irrigated agriculture. They grow rice, sugarcane, fodder wheat and gram in a well-developed and -maintained system with level fields. Private tubewells have been installed to compensate for the past unpredictability of canal water supplies.

Figure 4 shows canal water supplies to the system from 1980 to 1992. Three major periods can be identified: 1980–83, characterized by low supplies; 1983–88, in which flows were highly variable as supplies were disrupted during remodeling; and 1989–91, when supplies stabilized at new high levels as the remodeled canal came on stream.

Farmers reported that their water supplies were still inadequate during *kharif* (the summer), but sufficient or even excessive during *rabi* (the winter). Surprisingly, more than half the farmers along head watercourses complained that their supplies had decreased. Outlet structures had been modified during the remodeling, with open flumes being replaced by narrower adjustable proportional modules. In addition, the lining of watercourses meant that much of the extra water supplied could be passed to the tail of the system.

Increased canal water supplies have led to a sharp decrease in the number of private tubewells operated, from 40 in the early 1980s to only 8 today. For those that remain, the number of hours of use is lower than before remodeling, though still quite high (300–350 hours per month) during the relatively dry May to August period. Tubewell owners now find it hard to make ends meet.

THE CROPPING SYSTEM

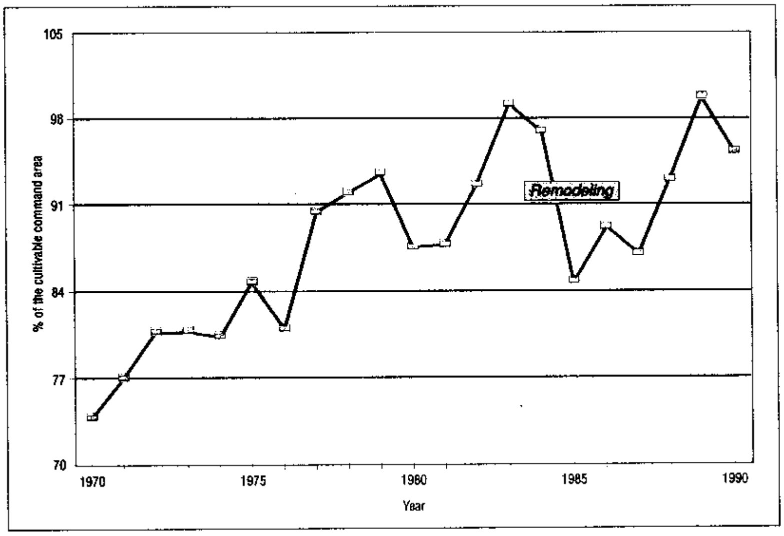
IIMI's researchers examined the effect of water supplies on cropping intensity, cropping patterns and crop yields.

Cropping intensity increased from 75 percent to 95 percent between 1970 and 1991, but is still well below its intended level of 150 percent (Figure 5). The unstable but rising trend over the period as a whole is not closely linked to remodeling. Until 1983, it reflected the development of groundwater use, the introduction of new crop varieties and the increased use of inputs. During the transition period, when supplies were unpredictable, cropping intensity fell. The decrease would have been even more dramatic had it not been for the alternative water supply provided by tubewells. After 1985, farmers abandoned their tubewells in favor of the extra canal water. The potential impact of the extra canal water was therefore partially offset by a decline in groundwater use. This shift did, however, reduce the costs of production, since canal water supplies are cheaper than tubewell water.

Figure 6 compares the cropping patterns of 1970 with those of today. The area under rice has risen steadily over the period, with some dents in confidence occurring during remodeling, but a rapid bounce back afterwards. Sugarcane also slumped during remodeling, but the subsequent recovery is even more pronounced. The trends for both these commodities suggest that farmers have invested much of the extra canal water in "thirstier" crops that offer a good cash return. This was confirmed through regression analysis.

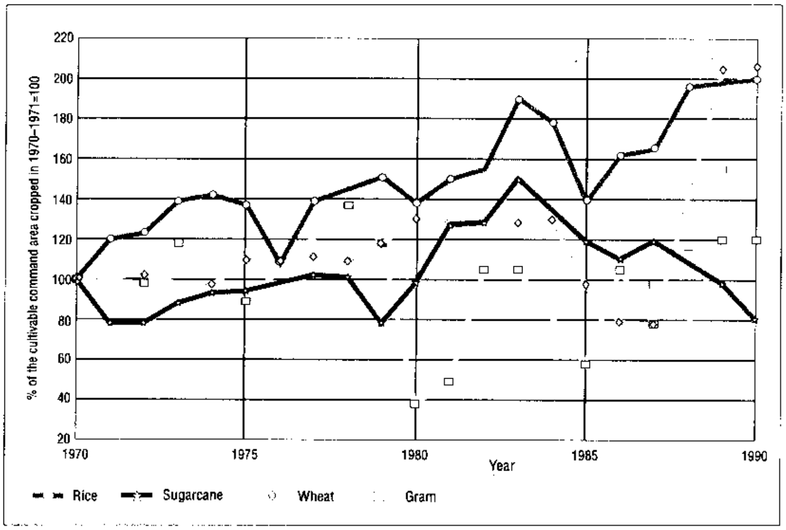
Wheat, in contrast, has fallen into decline since 1984, failing to recover after remodeling. It has lost out to sugarcane, with which it competes for both labor and land. Factors other than irrigation supply (such as rainfall) influence the cultivation of gram, for which there is no discernible trend. Orchards and vegetables have shown a slight increase since remodeling, but their overall share is still very low. Farmers may in time switch away from rice towards these higher-value cash crops, but are understandably cautious at present.

Figure 5. Changes in yearly cropping intensity in the Girsal Minor Command Area, 1970–1990.



Farmers reported large gains in crop yields. Heading their list was sugarcane, for which they claimed two- to threefold increases. Rice yields were also alleged to have risen dramatically, from 2.9 t/ha before remodeling to 5 t/ha since. Increases in wheat yields were said to be less impressive but still considerable, from 1.5 t/ha to 2.3 t/ha. Farmers' data on yields in the four watercourses were highly correlated with their impressions of changes in water supplies. Tail watercourses, which benefited most from the remodeling, were thought to have experienced higher in-

Figure 6. Relative changes in area of main crops in the Girsal Minor Command Area, 1970–1990.



tables have risen and waterlogging is becoming a problem. The study found some evidence to justify these fears, with farmers now closing their outlets for a higher proportion of time than previously.

creases than head watercourses. Farmers' impressions of yield gains are borne out by data supplied by the Provincial Irrigation Department for the whole Scheme, which indicate that yields of rice, wheat and sugarcane have increased by 18 percent, 25 percent and 45 percent, respectively, over the past 4 years.

Improved canal water supplies mean that farmers now face a less risky environment. They reported less variation in yields, with the result that they can count on more stable incomes and food supplies. They are also prepared to invest more in fertilizers, the use of which has increased dramatically in recent years. Water and fertilizer have thus acted together to increase yields, particularly in the case of sugarcane.

Higher supplies appear to have led to a slight decrease in the productivity of water, with a fall of 1 percent for rice and 17 percent for wheat following remodeling (Table 1). Both farmers and agency staff expressed the fear that, since the new canal became operational, water

Table 1. Average crop yields per unit of irrigation water (kg/m³).

Crop	Before remodeling	After remodeling
Rice	0.7	0.65
Wheat	1.15	0.95

IMPACT

Instead of expanding their cultivated area or increasing their cropping intensity, the farmers of Girsal Minor are using their extra water to grow two more crops with a high water requirement, rice and sugarcane. Given the yield gains and economic returns to these crops, this is a rational response. While the costs of water have fallen, the yields of both crops have risen sharply, making a substantial impact on farmers' net incomes with little extra demand for labor.

As a result, cropping patterns differ radically from those envisaged during the Scheme's design phase. At that time, it was assumed that farmers would use only 2 percent of their land to grow rice whereas, in fact, they are now using nearly 25 percent. A serious implication of this much greater area under rice is that farmers' water allocations are far higher than originally intended. This may have a negative impact on future supplies to farmers in later phases of the scheme, still under construction. If the areas under rice and sugarcane remain constant, cropping intensity is unlikely to rise much beyond its current level of 100 percent.

CONCLUSION

The provincial government has only partially succeeded in its objective of increasing agricultural production by increasing water supplies. If increased supplies to Paharpur lead to excessive waterlogging and/or to reduced supplies further downstream, the modest gains made may be offset by future losses.

EFFECTIVENESS AND EFFICIENCY: MAHI KADANA, GUJARAT, INDIA

Through its large size and abundant water supplies, the Mahi Kadana Scheme (Figure 7) has had a considerable impact on agricultural production over the 15 years since its completion. Farmers are able to cultivate over 90,000 ha of irrigated rice during *kharif*, and a similar area of wheat during *rabi*. Many also grow lucrative cash crops such as tobacco and banana, and a host of minor crops. Three crops a year can be raised in parts of the command area.

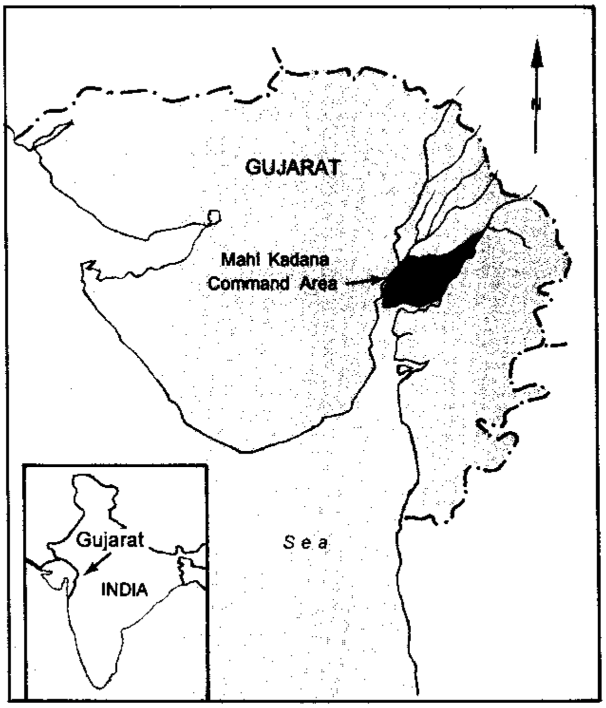
On the face of it, Mahi Kadana is thus a highly effective scheme, making a sizeable contribution both to the subsistence and incomes of local farmers and to the nation's food production and exports. However, a closer look at performance paints a less reassuring picture.

Mahi Kadana suffers from a problem typical of large-scale schemes—uneven water distribution. While head reaches are oversupplied, tail reaches are commonly deprived. On an estimated 20 percent of the Scheme, farmers have given up on canal water supplies altogether, resorting to the use of pumped groundwater alone. Uneven distribution has led to both waterlogging and salinization, which are now thought to affect between 7 and 10 percent of the command area. Water tables in some head reaches have built up to dangerously high levels. Yet groundwater exploitation, which could act as a stabilizing factor, is occurring almost exclusively in tail reaches.

What is going wrong? In theory, Mahi Kadana has the capacity to exercise tight control over water distribution. Gate structures are installed at even the lowest levels of the system.

To find out, IIMI launched a study in two distributaries, Umreth and Borsad, located in the upstream and downstream portions, respectively, of the Scheme's right bank command area. This study formed part of a broader one on main system management being conducted by IIMI and two State entities, the Institute of Rural Management (IRMA) and the Water and Land Management Institute (WALMI).

Figure 7. The Mahi Kadana Command Area, India.



The study found conditions typical of those on the Scheme as a whole. Canal water was oversupplied in the head reaches of both distributaries, where continuous flooding frequently restricted farmers' choice of crops and input use. Tail-end areas, in contrast, were deprived, especially in the downstream Borsad Distributary. Farmers here had resorted to the Scheme's highly active market in pumped groundwater to meet their needs. While aquifers in head-end areas had reached near-saturation point, those at the tail were overexploited and were in urgent need of recharging.

At the root of the Scheme's problems was an arcane system of water allocation and delivery that had lost credibility with farmers (see Box, p.11).

THE OFFICIAL SYSTEM OF WATER ALLOCATION AND DELIVERY

In theory, the system works as follows. Prior to each season, staff of the Irrigation Department estimate total water resources and determine the area that can be irrigated, before informing farmers of their authorized cropping pattern. Farmers then make individual applications to receive irrigation water, using a numbered form which must be certified by a village official known as the *talati* before being submitted to the agency's junior field officers. The form entitles farmers to receive water during each of the rotation periods specified by the Irrigation Department.

Two types of lower-level agency staff are responsible for administrating the system. A *karkoon* or field assistant assigned to each canal "beat" processes farmers' applications for water and has daily operational responsibility for matching supplies with demand. Each *karkoon* is supported by four or five *chowkidars*. These irrigation laborers interact with farmers at outlet level, passing requests for water to the *karkoon* and recording deliveries to farmers during each 2-week rotation period. This information is subsequently used for billing purposes.

Farmers who use water without applying for it are issued with an *ekrarnama*—a notice certifying the land area and period of irrigation involved. They are penalized by being charged 1.5 times the regular water rate. Persistent offenders become ineligible for water supplies the following season.

The farmers interviewed by IIMI were unanimous in their opinion that the procedures for applying for water were tedious and time-consuming. In particular, the village *talati* was seldom available when needed.

Even if it had been consistently applied, this system would not have resulted in efficient operations. It gave insufficient guidance on what to do if the water supply fell short of demand. There were no procedures for assessing water requirements for crop mixtures. The rule-of-thumb method used to calculate total water demand ensured allowances well in excess of the needs of even the thirstiest crop grown on the scheme, namely rice. Areas irrigated by groundwater were ignored in the calculations.

In practice, only 30 to 40 percent of farmers followed the official system, so unauthorized irrigation accounted for the bulk of water deliveries. The result was a state of near anarchy in which most of the Scheme's stated rules were flouted (Table 2). Many farmers took two turns within a rotation, at others' expense. Manipulation by breaching and cross-bunding were common at peak demand periods. Farmers often constructed unauthorized outlets and laid pipelines direct to their fields. The more resourceful had even established mini water-markets for the supplies obtained in these ways. Many agency staff appeared to have given up trying to make the system work. *Chowkidars* and *karkoons* were rarely at sluice gates when water was required, so farmers often had no choice but to operate the gates themselves. Supervisory staff visited canal sites only when breaches or damage to physical structures occurred. One section officer admitted that he had never visited any interior canal reach apart from the site of the head regulator, as to do so he would have had to cycle or walk several kilometers. Section officers were expected to check 20 percent of irrigated areas to verify farmers' compliance with authorized cropping patterns, but this was rarely done.

Some officials turned a blind eye to malpractices; a few actively connived with them. There were several cases in which field staff were alleged to have been "persuaded" by farmers not to issue them an *ekrarnama*. The figures for area irrigated and water delivered were not infrequently cooked so as to reduce the water bills of "influential" farmers. A large proportion of bills were not recovered, as farmers faced few sanctions for not paying them. Farmers at the tail end of the Scheme

Table 2. De jure rules and de facto operations of the secondary canals.

De jure	De facto
1. Applications/indents must be submitted to receive water.	Unauthorized irrigation forms the bulk of water supplies.
2. Farmers are not permitted to operate outlet gates or tamper with physical structures.	Head-end and other powerful farmers open and close outlet gates at will.
	Cross regulators and minor gates are opened and closed by farmers at night. Minor gate rods are removed to obtain a low level of discharge when minors are closed.
3. Water conveyance structures (except for field channels) are not to be installed without special permission.	There is a proliferation of illegal outlets, with direct pipelines laid to many farmers' fields.
Obstructing water flow by farmers in distributaries and minors is illegal.	Farmers frequently resort to raising canal water levels by blocking minors with obstructive materials (including broken pieces of canal lining) and then irrigating through pipes or outlets.
	Minor beds are cut to take water directly to fields.
4. It is illegal to obtain water from an outlet of a different command.	Tail-end farmers often resort to securing water from adjacent outlets.
5. Field staff must inform farmers in advance about water canal closures.	Such decisions are usually made ad hoc and are often not communicated to farmers.
6. Field staff must maintain accurate outlet command area records and maps.	Outlet command boundaries and farm holdings change, but records are often not updated.
	Chowkidars keep records of area irrigated, duration of turn, etc., mainly through guesswork.
	In some cases, farmers who irrigate without authorization "persuade" officials not to issue them with *ekrarnama*.
7. Senior supervisory staff are responsible for visiting and assessing progress.	Responsibilities are often shirked. Adequate assistance and protection are not provided to lower-level staff.
8. More than one irrigation per fortnightly rotation is not authorized.	Those who gain access to water deliveries resort to duplication of turns.

often exerted pressure for reform of the system, but their pleas went unsupported by the head-end farmers who benefited from the current lax regime.

Under these circumstances it is hardly surprising that farmers at the tail end had lost interest in obtaining canal water. The availability of pumped groundwater provided them with a reliable, if more expensive, alternative source of supply.

IIMI and its partners are searching for ways of improving the efficiency of the Mahi Kadana Scheme. Among the innovations being tested is a computerized management information system, designed to help managers identify problem areas more accurately and rapidly. Introduced on a trial basis in 1993, this system has already revealed opportunities for redistributing water between head and tail sections.

CONCLUSIONS

Mahi Kadana's impressive impact on agricultural production stems from the plentiful availability of water, not from its efficient use. Many of the Scheme's operational problems are caused by its inefficient system of water allocation and delivery. A rising tide of indiscipline and frustration among users threatens the Scheme's future viability.

Less water, better spread over the system, should be the major objective of efforts at reform. Redistributing canal water would exert a healthy downward pressure on groundwater prices, giving poorer farmers greater market access. It would also take the pressure off tail-end aquifers.

The problems of Mahi Kadana will not be solved overnight. By providing managers with a more accurate picture of performance, a computerized management information system will undoubtedly help. But it will have to be accompanied by stricter supervision of operations, including the enforcement of existing regulations.

ADEQUACY VERSUS RELIABILITY: FORDWAH/EASTERN SADIQIA, PAKISTAN

Groundwater—a reliable alternative source of water for tail-end farmers.

If you were a farmer, would you prefer a supply of canal water that was sufficient to meet your needs in overall quantity but whose arrival was unpredictable, or a supply that was regular but fell somewhat short of your needs?

The answer, of course, is "that depends." Just how unpredictable? Just how far short of needs? IIMI has been studying the trade-off between adequacy and reliability in the Chishtian Subdivision, which forms part of the Fordwah/Eastern Sadiqia System of Pakistan's Punjab (Figure 3, p.6). Conducted in collaboration with the French Centre National du Machinisme Agricole, du Génie Rural, des Eaux et des Forêts (CEMAGREF), this research complements efforts to develop and introduce management information systems that will improve operational efficiency by ironing out fluctuations in discharge rates.

TWO APPROACHES

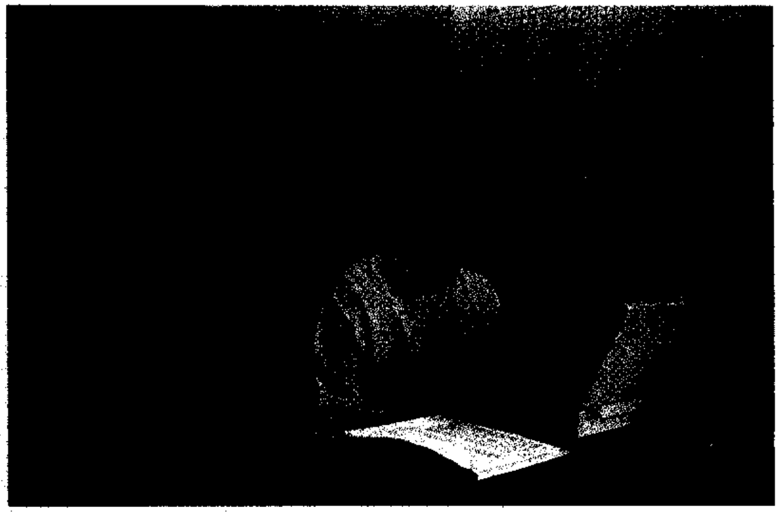
Forecasting the impact of changes in canal water supplies on agricultural production is difficult, especially when farmers have access to alternative supplies in the form of pumped groundwater. The challenge facing the IIMI-CEMAGREF team is to develop cost-effective methods that provide a clear picture of performance without requiring exhaustive efforts in data collection and analysis.

Two approaches have been tested so far. The first takes the watercourse—the basic unit of the irrigation system—as the subject of analysis. Information on canal water supply (independent variable) and cropping intensity, cropping pattern, yields and tubewell operation (dependant variables) are collected for a sample of watercourse command areas, and analyzed using standard statistical methods. This approach may be thought of as corresponding with the professional viewpoint of Irrigation Department staff as they go about their work.

In the second approach, farm-level analysis is complemented by economic modeling. By taking the farm as the basic unit, this approach comes closer to reality, enabling users to put themselves "in the shoes" of the farmer. The researchers analyze farms in selected watercourse command areas according to the characteristics of their irrigation water supply. They then develop economic models to explore the relationships between irrigation water supply, farmers' decisions and agricultural production.

Over the past 3 years, the team has applied these two approaches in the Fordwah Branch Irrigation System. Data for the watercourse-level approach were collected along 8 sample watercourses of the Azim and Fordwah distributaries. In the farm-level approach a specific farm, selected according to a previously developed typology, was used as a case study. The software CROPWAT, developed by the Food and Agriculture Organization (FAO), was used to

H. M. Hemakumara



Models allow users "to put themselves in the shoes" of the farmer.

establish the relationship between water supply and yields. Different scenarios were then modeled using linear programming.

The researchers used two simple indicators to describe the adequacy and reliability of water supplies along the sample watercourses. The first was the seasonal delivery performance ratio (DPR), which is defined as the average ratio of actual discharge over design discharge in each cropping season. The second was the coefficient of variation of the daily delivery performance ratio (CV-DPR), which captures fluctuations in discharges.

Over the 3-year period, both indicators showed considerable variability. Predictably, tail-end locations suffered the worst fluctuations in supply. Many tail-end farmers used tubewell water only and did not take canal water into account in their decision making.

How successful were the two approaches in identifying the impact of this variability? The watercourse-based approach yielded some interesting information, but interpretation was hampered by the small sample size and the few variables that could be included. No clear relationship emerged between canal water supply and cropping pattern or intensity (see Box).

RESULTS OF THE WATERCOURSE-BASED APPROACH

As canal water supply increases, farmers should be in a position to expand the area they cultivate. The analysis suggested that they are unlikely to do so by very much. For example, an increase in the DPR from 0.5 to 1 (equivalent to doubling the supply) was apparently accompanied by an increase in area cultivated of only 6.5 percent.

Two explanations are possible. Either farmers are increasing their cropping intensity—cultivating more crops in the year—or they are altering their cropping patterns—applying more water per unit area to crops with a higher water requirement, such as rice and sugarcane.

Cropping intensity appeared to be more strongly correlated with the seasonal DPR of phe previous year than with that of the current year. This suggests that farmers rely on their past experience when making their cropping choices.

With regard to cropping pattern, no increase in the percentage area cultivated to rice or sugarcane could be detected. The only clear correlation to emerge was between the DPR and the area under fodder.

The DPR was negatively correlated with tubewell water supply, indicating that farmers do indeed substitute between these two sources.

Developing robust relationships between the variables using this approach would require the inclusion of many more sample watercourses, implying relatively high costs in data collection.

The farm-based approach yielded more complete information. Table 3 shows the main characteristics of the sample farm selected for the modeling exercise. This farmer had relatively good control over his water resources. Not only did he own a tubewell, but his land lay in the command area of the Fordwah 46-R Watercourse, which had one of the highest DPRs (1.46) and one of the lowest CV-DPRs (0.43).

Table 3. Characteristics of sample farm used in the farm-based approach.

Variable	Sample farm
Farm characteristics	
• Area cultivated	10.1 ha
• Tenure status	Owner-cum-tenant
• Tubewell owner	Yes (PTO*)
• Household members	5
• Permanent labor	1
Irrigation water supply	
• Watercourse	Fordwah 46-R
• Position along watercourse	Middle
• Water turn duration	9 hours 45 minutes
• Tubewell discharge	28.3 l/s
• Tubewell operation costs	275 Rps/1,000m^3
Agricultural production	
• Cropping intensity (year)	140%
• Area under cotton	55%
• Area under sugarcane	12%
• Area under wheat	55%

(* PTO = power-take-off tubewell.)

The researchers modeled the farm on computer, using actual DPR and actual CV-DPR to calibrate the model. They then calculated the effect of changes in canal water supply on the farm's total gross income, income per unit area and income per unit of water. To separate the impact of discharge amounts from that of discharge variability, three scenarios were simulated: design discharge (DPR = 1) with no variability (CV-DPR = 0); actual discharge (recorded DPR) with no variability (CV-DPR=0); and design discharge (DPR = 1) with actual variability (recorded CV-DPR). Table 4 shows the results.

Table 4. Impact of three canal water supply scenarios on sample farm income.

Indicator		Reality	Simulating		
		Recorded DPR and recorded CV-DPR	Recorded DPR and design CV-DPR	Actual DPR and recorded CV-DPR	Design DPR and design CV-DPR
Total gross income (US$)		35,370	57,440	32,310	50,790
Gross income per unit of water (US$/ha)		3,500	5,680	3,200	5,020
Gross income per unit of water (US$/'000m^3)		400	500	410	540
Tubewell pumpages	Total (m^3)	56,700	45,100	57,100	46,700
	% of total supply	64	39	72	50

It can be seen at a glance that reducing the *variability* of canal water supply has a much greater positive impact on incomes than changing its quantity. For example, adjusting the supply to the design level without altering its variability would decrease total gross income by Rs 3,060 (approximately US$97.14), whereas eliminating variability would increase it by Rs 22,070 (approximately US$700). This suggests that farmers would be willing to tolerate a reduction in their canal water supply provided this is offset by increased reliability.

The effect of canal water supplies on the use of pumped groundwater was also built into the simulations. As expected, owning a tubewell strongly influences the different scenarios, making farmers less vulnerable to changes in canal water supply. Tubewells have a dual role, both compensating for reductions and attenuating fluctuations.

CONCLUSIONS

Of the two approaches studied, the second, based on farm-level analysis supported by modeling, seems to offer better value for money. It shows good potential for analyzing the impact of canal water supply on agricultural production and incomes. This approach fits more closely with reality by modeling the behavior of the actual decision maker, the farmer. It requires more detailed analysis of farming systems and of constraints to production, but fewer data overall.

The results of the modeling exercise suggest that reliable water supplies are more important to farmers than adequate water supplies, provided shortfalls do not exceed about 10 percent of crop water requirements. This in turn suggests that operational improvements should meet with farmers' approval.

Theme 2 Water Delivery and Disposal

INTRODUCTION

Put simply, the task of the irrigation manager is to deliver water to farmers in the right amounts and at the right places and times. If excess water is delivered, it must be drained and, if possible, recycled.

To perform well in this crucial area, managers need accurate, up-to-date information. Data on farmers' cropping patterns and the water requirements of crops serve as the basis for setting water delivery targets. Records of the deliveries actually made enable trouble-spots in the system to be identified and corrective action to be taken. Here the speed with which information can be collected and processed, as well as its accuracy, is an important attribute.

The new information technology developed over the past 15 years has created exciting opportunities to improve irrigation operations and maintenance. Many irrigation systems around the world are currently experimenting with computer-based tools developed by IIMI and other organizations. In 1994, IIMI launched a network to link tool users with each other and with tool developers, so as to improve the dissemination of knowledge in this fast-moving field (see Box).

A NETWORK IS BORN

In 1986, IIMI's researchers launched a project to strengthen water allocation and delivery at Sri Lanka's Kirindi Oya Irrigation System, which suffered from severe water shortages. An important part of the project was the development of a user-friendly computer model to simulate hydraulic conditions in the main canal. The design of the model was subcontracted to the Centre National du Machinisme Agricole, du Génie Rural, des Eaux et des Forêts (CEMAGREF).

Thus began a fruitful partnership which led to the launching, 8 years later, of the Information Techniques for Irrigation Systems (ITIS) Network. The research at Kirindi Oya culminated in the first prototype of the Irrigation Management Information System (IMIS), a set of simple databases designed for ease of use and adaptability to different locations. This and other software packages were subsequently tested, first in Pakistan and Mexico, and then in several other countries. In 1992, the two institutions organized an international workshop, held in Montpellier, France, to analyze and compare experiences in the use of computer tools in irrigation management. Participants expressed the wish for a formal network that would serve as a continuing means of exchanging experiences. The outcome was the first issue of the ITIS Newsletter, published and distributed by IIMI in November 1994.

The Newsletter has three major sections. The "Forum" section carries major network news items and features of general interest. This is followed by "ITIS in the Field," a platform enabling those in the front line to describe their experiences in applying information technology in specific irrigation systems. The first issue has contributions from the Kirindi Oya Irrigation System in Sri Lanka, the Muda Scheme in Malaysia, the La Begoña and Rio Yaqui irrigation districts in Mexico, the Fordwah/Eastern Sadiqia area of Pakistan and the Mahi Kadana System in India. The Newsletter's third section is devoted to "Tools and Techniques," allowing readers to keep abreast of technical developments.

This year's report on the Water Delivery and Disposal theme starts with a study of Sudan's Rahad Irrigation Scheme which shows how inaccurate information can undermine system management and the efficient use of water. There is no point in developing a more sophisticated decision support or management information system if the basic data fed into it will be wrong. Next, we turn to the Chishtian Subdivision in the Punjab of Pakistan, where IIMI and its partners have used modeling as a tool in the development of proposals to improve water distribution. Last, we report on the successful introduction of a modern management information system to the Mahi Kadana Scheme of the Gujarat State in India, where tighter management is urgently needed to combat indiscipline.

FIELD STUDIES

Misleading Statistics: The Rahad Scheme, Sudan

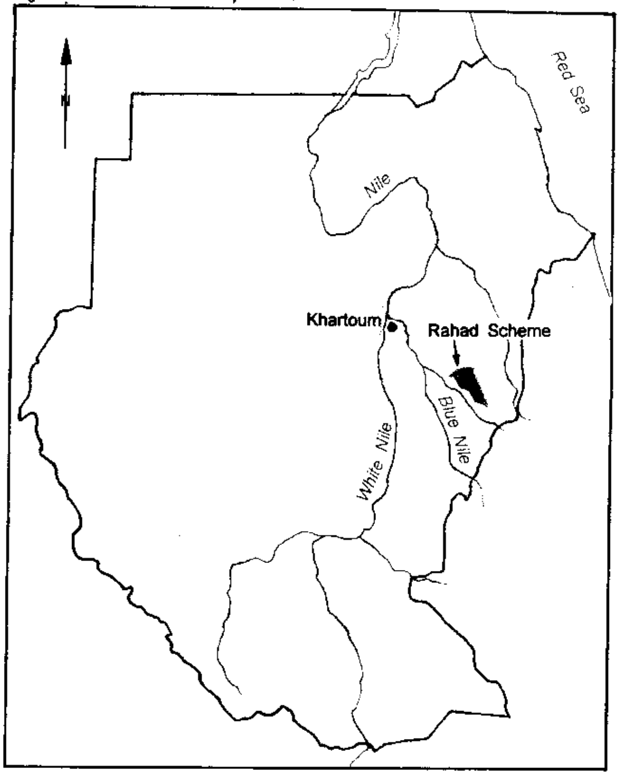
Sudan's Rahad Irrigation Scheme is one of the country's largest and newest. Phase 1, opened in 1981, has a command area of 126,000 ha. This will rise to 345,000 ha once Phase 2 is completed. The Scheme lies on the east bank of the Rahad River, about 300 km southeast of Khartoum (Figure 8).

Although built much later than the Gezira Scheme, Rahad was designed along the same lines. Adequacy and reliability of supplies, combined with their equitable distribution, are the major design objectives. In 1990, IIMI began a 3-year study on Major 5, one of the Scheme's 10 major canals, to find out whether these objectives were being met.

The answer, on the face of it, was "yes." As at Gezira (see IIMI's 1993 Annual Report), performance looked quite good when analyzed at control points or in terms of whole canal sections. However, studying water distribution at this "macro" level paints a rosy picture of reality.

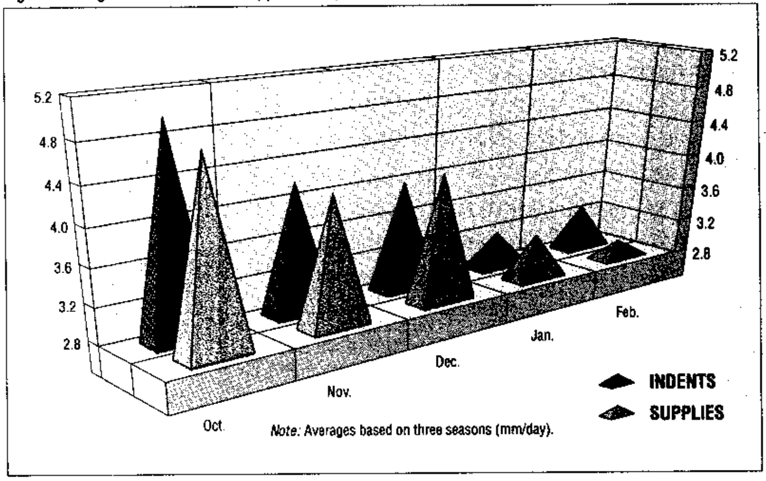
Like the Gezira, Rahad operates according to what is known as an indent system. Indents are estimates of crop water requirements made on

Figure 8: The Rahad Scheme, Sudan.



the basis of command area and cropping pattern. At Rahad, indents for each distributary are calculated by the Rahad Agricultural Corporation, which then "places" them with the Ministry of Irrigation—the agency responsible for actually delivering water. The Ministry's officials are supposed to adjust gate-settings in line with indents at each control point along the canal.

Figure 9. Irrigation indents and supplies, Major 5, 1991–1993.

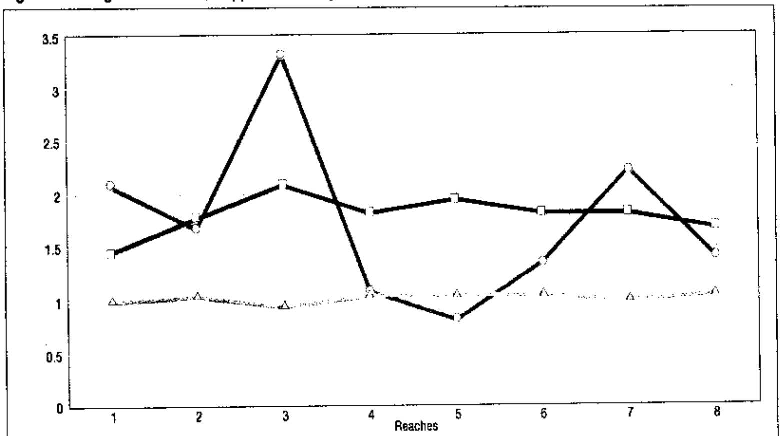


Averaged over 3 years, monthly water supplies appeared well matched with indents when viewed at macro level (Figure 9). However, this harmony fell apart when the data were analyzed according to individual canal reaches (Figure 10). In almost every reach, indents and supplies differed greatly. Distribution was, in fact, highly erratic, with some reaches receiving far less than their indents and others far more.

Worse still, indents bore little relationship to real needs. This emerged most clearly when the statistics were analyzed on a monthly basis. As crops mature from October to February, their water requirements can only move in one direction—downwards. Yet indents frequently did not follow suit. In two out of the three seasons studied, they showed no discernible trend whatsoever. In the third, there was a reduction from October to February, but it was too little in some reaches and too much in others. Overall, indents were about 80 percent higher than estimated needs during the study period, suggesting a serious problem of oversupply.

Comparing actual supplies with crop water requirements as calculated by IIMI revealed further anomalies. In 1991-92, three reaches received more supplies in February than in October. The other five had more water in October, but in some cases by only a small margin. In 1992-93 and 1993-94, October supplies were always greater than those in February—but that does not mean that they matched requirements: in the middle reaches (R4 to R6), October supplies were only about half the required amounts.

Figure 10. Irrigation indents, supplies and requirements for individual reaches, Major 5, 1991–1993.*



	1	2	3	4	5	6	7	8
▲ Irrig. Req.	1	1.05	0.95	1.05	1.05	1.05	1	1.05
● Supplies	2.09	1.68	3.32	1.09	0.82	1.36	2.23	1.41
■ Indents	1.45	1.77	2.09	1.82	1.95	1.82	1.82	1.68

Note: *Ratios of irrigation indents, supplies and requirements to an average irrigation requirement considered as a reference parameter.

The researchers concluded that actual water supplies were in agreement neither with indents nor with real needs for most of the year throughout most of the project area.

The problems revealed by IIMI's study can be tackled through suitable interventions. The Box (p.19) presents some of the recommendations made to the two agencies concerned.

RECOMMENDATIONS TO THE AGENCIES

* The agencies should collaborate in the development and implementation of a more effective system of indenting on the basis of real needs.

* Supplies should be better matched with needs, as redefined through the reformed indenting system. In particular, water distribution at the tertiary level should be more systematically planned, implemented and monitored.

* To aid in monitoring, control structures should be calibrated to allow flow measurement.

* The widespread problem of surface waterlogging should be recognized and addressed as a matter of urgency.

* The use of surface drainage facilities should no longer be restricted to rainwater only, but should be extended to allow the draining of surplus irrigation water.

* Communications along major canals should be strengthened by providing gate operators with suitable equipment, including walkietalkies.

* The transport problems facing field staff should be addressed by equipping them with vehicles such as motor cycles where necessary.

* Financial incentives should be offered to staff for good performance.

CONCLUSIONS

These results point to a serious problem of over-indenting and oversupply in the Rahad Scheme, with about 70 percent more water being delivered than is actually needed. However, at individual reach level there are cases of both oversupply and undersupply.

Assessing the performance of an irrigation system at only the macro level is misleading. The evaluation of deliveries to individual reaches helps pinpoint problems, allowing more effective interventions to improve performance.

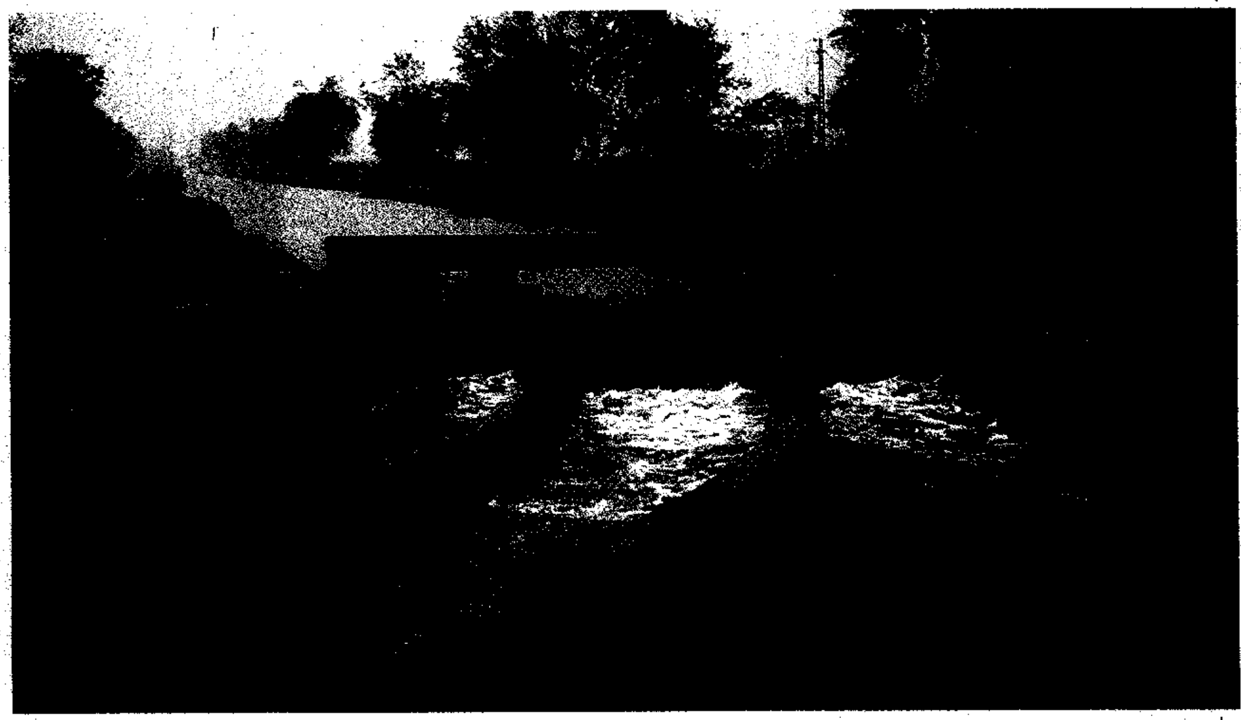
COMPUTER APPLICATIONS

M.S. Shafique

Indents often bear little relationship to real needs.

Unmaking Waves: The Chishtian Subdivision, Punjab, Pakistan

Besides being chronically short of water, irrigation systems in the Punjab of Pakistan are prone to sharp fluctuations in water supplies. Some fluctuations occur naturally, as river levels rise and fall according to seasonal rainfall and to snow or glacial melt. Others originate in the physical characteristics of the systems themselves (see Box p.20).



The complexity of the Punjab's canal network poses special challenges for management.

HOW WAVES ARE CREATED

The Punjab's vast and complex network of canals, in which water must often travel long distances to reach its destination, poses special challenges to the agency responsible for managing it, the Punjab Irrigation Department (PID).

Fluctuations in supply tend to become more extreme as they pass further down the canal system. Each operator responds to a fluctuation by attempting to maintain discharges to his branch or distributary at their target level. This is done using a gated structure known as a cross-regulator. If discharges in the main canal fall, the operator adjusts the cross-regulator so as to increase the proportion of the flow entering the distributary. This has the effect of reducing still further the amount of water passed on to the next operator down the main canal. When discharges rise, the cross-regulator is again adjusted, this time to decrease the proportion passing to the distributary, thereby increasing the amount of water passed down the main canal. The result is a "wave" effect that gathers momentum as it moves down the system.

Fluctuations are especially acute in the Chishtian Subdivision which lies fairly far down the hierarchy of the Punjab's waterways. The Subdivision derives its water from the Fordwah Canal, which issues from the Suleimanki Barrage. This in turn is fed by a series of long link canals.

The fluctuations are associated with an overall shortage of water. Supplies fall short of demand throughout the year, except occasionally during the main rainy season. When there is not enough water, the PID rotates supplies between the Subdivision's four major distributaries: Daulat, Shahr Farid, Azim and Fordwah.

To diagnose the Subdivision's problems in more detail, IIMI's researchers analyzed the distribution of water in the Fordwah Branch over a 10-day period in June-July 1994. As expected, they found shorter than recommended rotations and an excessive number of gate operations, especially towards the tail end of the branch (see Box below).

OPERATIONS IN THE FORDWAH BRANCH

The PID's rules state that supplies should be made available to a distributary for a period of at least a week at a time—enough to allow a complete cycle of *warabandi* (farmers' canal turns). Analysis of the 10-day study period showed that supply periods were, in fact, much shorter, with gates being opened and closed at 2- or 3-day intervals. Data for the whole season suggested that this is common practice, due largely to the pressures placed on local operators by farmers.

The analysis also showed that the number of gate operations increased dramatically towards the tail end of the Fordwah Branch. Some of these operations were drastic, with gates being changed by up to 25 cm at a time as operators attempted to cope with frequent wild swings in water supply. There were days when the last operator on the Branch made hourly adjustments to gate settings. Fluctuations recorded at the Suleimanki Barrage were few and small throughout the 10-day period, so these operations were largely reactions to man-made fluctuations originating within the Fordwah System and the Chishpian Subdivision.

Operators displayed considerable skill in keeping supplies constant to canals when these were at first priority in the rotation, but canals at second or lower priority levels fared badly.

The researchers' next step was to conduct a modeling exercise to gauge the effect on system efficiency of operational decisions that would smooth out the waves. They used a hydraulic model known as SIC (Simulation of Irrigation Canals) that had been jointly developed by IIMI and CEMAGREF.

Two scenarios were examined. The first was an "improved localized control" scenario, in which local managers were kept largely responsible for operations at their regulation point. In this scenario it was assumed that gate settings would not be adjusted if discharges remained within 10 percent of target levels. The second was a more radical scenario, known as "centralized feed-forward control." Here the system manager controls all operations, taking decisions that anticipate future targets and fluctuations.

The researchers conducted two case studies to demonstrate the potential of the two scenarios for stabilizing supplies in different parts of the Fordwah Branch System (see Box below).

TWO CASE STUDIES

Case 1 examined operations at regulation point D245, near the head of the system, where the Daulat Distributary takes off. The operator here had changed the gate settings of the regulator 17 times during the study period, creating many downstream fluctuations in the main canal. Under the localized control scenario, the number of operations at D245 was reduced to six, with the result that most of the downstream fluctuations were smoothed out (Figures 11a and 11b).

Case 2 was at points D353 and D371, towards the tail of the system. During the study period the number of operations at D353, the last cross-regulator on the Fordwah Branch, exceeded that at all others, reaching four a day. Again, many of these operations became superfluous under the improved localized control scenario. Most fluctuations were smoothed out, with a beneficial effect on water distribution at the tail.

Results using the centralized feed-forward control scenario were still more impressive, leaving few fluctuations and none of more than 10 percent.

Figure 11a. Actual operations at Regulator RD245.

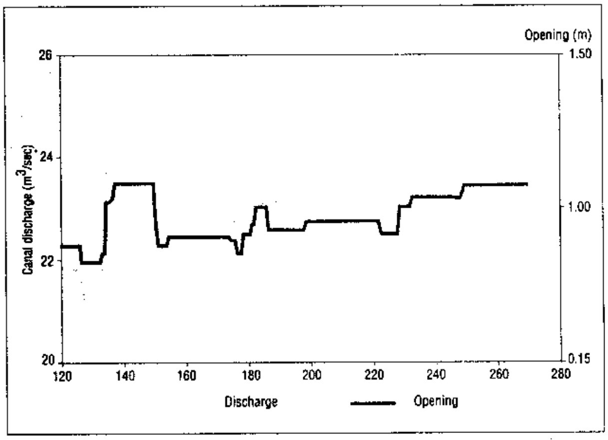
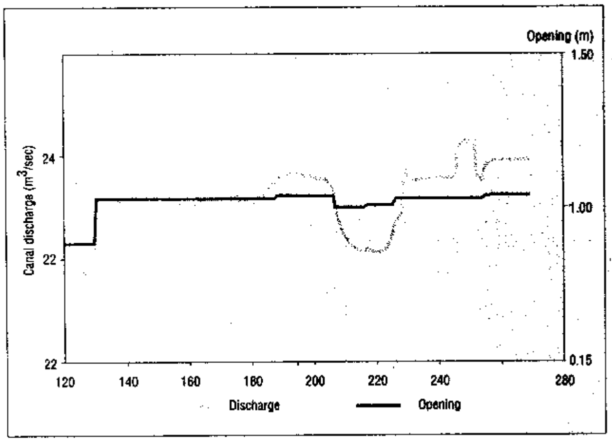


Figure 11b. Improved operations at Regulator RD245.



Extrapolating from the case studies to the System as a whole, the researchers estimated that operations could be reduced by more than half under the improved localized control scenario, while in the feed-forward scenario only one or two operations a day need be carried out at most regulation points. As a result, the fluctuations experienced at present could be largely attenuated. Those received at the head of the system could be passed on to the distributary whose turn it is to receive low priority.

When the team presented its results at a seminar, agency staff were more receptive to the improved localized control scenario. This is closer to existing practices and would therefore be easier to implement. Introducing the centralizad feed-forward control system would require tighter supervision and improved communications up and down the chain of command.

In a linked study, researchers are investigating whether reduced fluctuations will translate into real gains in the productivity of irrigated agriculture.

CONCLUSIONS

The modeling exercise demonstrated that:

* Even in the water-short Chishtian Subdivision, not more than one distributary at a time need suffer reduced supplies. A 7-day period of reduced supplies would take into account the *warabandi* cycle used by farmers and minimize downstream fluctuations in the Fordwah Branch.

* By resisting the temptation to intervene when distributaries are receiving 90 percent of their target discharge, operators could render many operations superfluous, decreasing variability in supplies downstream. This would greatly benefit farmers at the tail end of the system.

STREAMLINING DATA COLLECTION AND ANALYSIS: MAHI KADANA, INDIA

Introducing computerized aids to decision making can bring about a quantum leap in operational efficiency in complex, large-scale irrigation schemes. But such tools depend critically on effective data collection, a system which must be already in place when the tool is introduced. Experience in the Mahi Kadana System of the Gujarat State, India provides a textbook example of this principle at work.

Diagnostic studies revealed major shortcomings in the Scheme's existing data collection system. The information generated was not standardized and there was considerable overlap, with several agency staff collecting the same data. Information was recorded in different registers at different levels, making the analysis of performance a laborious task. No information was collected on several issues vital for monitoring performance, including the use of groundwater to supplement canal water. Crop yields could not be analyzed for specific outlets, making it impossible to pinpoint problem areas. Most seriously, from the agency's point of view, the billing of farmers was subject to major delays and errors.

In a joint project with the Gujarat Irrigation Department and the Water and Land Management Institute (WALMI), IIMI researchers set about devising a new data collection system. Intensive but informal discussions were held with agency field staff to identify needs.

The result was the "Red Book," a new data format uniting all the information previously scattered in different places and on different forms. Starting in the 1991 *kharif*, the researchers introduced the Red Book along a single section of the Mahi Right Bank Canal. Agency staff were trained in its use, and IIMI researchers were on hand to provide help where needed.

After a year, the agency staff were brought together and asked for their opinions. The Box below reproduces some of the things they said.

REACTIONS OF AGENCY STAFF

"Earlier we had to write the name of each irrigator, survey number, area, crop and date, and had to get the signature of the irrigator...Now we have to write only the actual date of irrigation...This saves a lot of time and stationery."

"The actual irrigation performance of the outlet...can be worked out easily, and water accounts and demand statements can be prepared quickly."

"Errors in recording are minimized."

"If any irrigator takes water twice in a rotation, it can be easily detected."

"All the information regarding the land use pattern of any outlet in terms of area irrigated by canal, area irrigated by wells, area having conjunctive use and so on, is available quickly and reliably."

"Progress reports...can be prepared quickly and accurately. All the information regarding irrigation performance...can be compiled and transmitted in one day, whereas four to five days were required earlier."

"This saving (of 1 hour per agency official per day) roughly amounts to Rs 1,000,000–1,500,000 per year at project level."

"The data collection system will be helpful for monitoring performance in terms of equity and reliability."

The success of the new data collection system encouraged managers to extend its use rapidly. It has now been adopted as the standard reporting system throughout the 212,000 ha of the Mahi Kadana Scheme, and is currently being introduced to other large-scale schemes in the Gujarat State.

To make better use of the information contained in the Red Book, the researchers went on to devise and introduce a computerized information storage and retrieval system. Known as Mahi MIS, the system consists of a series of interrelated databases, all in d-Base format, covering basic inventory, seasonal performance, and a summary of performance at system level.

Because an effective data collection system was already in place, the Mahi MIS could be integrated directly with the normal working practices of the Irrigation Department staff who were able to conduct data entry and retrieval after a short training at WALMI. The staff have used the system on a trial basis in the Kunjarao Section of the Scheme's Ode Subdivision since the 1993 *kharif.*

Experience so far suggests that the Mahi MIS could bring major gains in efficiency. Managers will be able to find out about performance in any part of the Mahi Kadana Scheme at a moment's notice, instead of having to wait until after the season, as at present. In addition, it will be possible to generate farmers' irrigation bills promptly at the end of each season.

Originally developed merely to replicate data already used by the agency, the Mahi MIS is now being used to provide information on a wider set of performance indicators. This will allow managers to focus not only on specific operational problems, such as the use of a particular cross-regulator, but also on broader strategic issues, such as the effectiveness of rotational irrigation in achieving equitable and reliable water deliveries.

Because performance can be analyzed according to different hydraulic units (such as outlet or canal), or at different levels in the administrative hierarchy (such as field assistant, section officer or subdivision officer), managers will be able to pinpoint the source of problems more accurately, helping to combat the Scheme's rising levels of indiscipline.

The Mahi MIS has already been used to undertake a comprehensive evaluation of performance in the Kunjarao Section. This exercise revealed major opportunities to improve the distribution of water to tail sections at both the beginning and end of the season, helping marginalized farmers to bring forward their planting dates and avoid terminal drought.

CONCLUSIONS

Computerized tools to aid decision making can be successfully introduced when an effective data collection system is in place at lower levels of the irrigation system.

The Mahi MIS is a powerful tool for improving the productivity of irrigated agriculture.

Theme 3 Public Irrigation Organizations and Policies

INTRODUCTION

Developing-countries often experience long time-lags between the generation of new irrigation management technologies and their adoption by managers. The supply of innovations that, if adopted, 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. Well-judged reforms in both these areas could bring considerable benefits.

This year's report features four studies in which organizational and policy issues are closely interwoven. In the first, we visit Pakistan's Land Reclamation Directorate—an under-resourced institution with an important mandate for the sustainability of that country's irrigated agriculture. Second, we turn to the performance of cooperatives in Niger, where market forces and a lack of government support are undermining farmers' allegiance. Our third study examines the impact of market-oriented policy reforms at irrigation district level in China. Last, we return to Pakistan to assess the policy implications of expanding water markets in the Fordwah/ Eastern Sadiqia area of the Punjab.

Salinity continues to be a common problem for tail-end farmers.

ORGANIZATIONS

Combatting Soil Salinity... or Not: Pakistan's Land Reclamation Directorate

The build-up of salt deposits in farmers' fields is a common problem in the tail areas of irrigation systems, where farmers use pumped groundwater to make up for shortfalls in the delivery of canal water. One solution to the problem is to leach out the salt using extra supplies of canal water provided specifically for this purpose. Organizing this process in the Punjab of Pakistan is the responsibility of the province's Directorate of Land Reclamation (DLR). The Directorate was established in 1945 as a special unit of the Provincial Irrigation Department.

In 1992–93, IIMI collaborated with the Directorate in an evaluation of its procedures and impact. The study covered 20 sample watercourses in the Lower Chenab Canal East Circle. The Lower Chenab is one of the biggest and most complex of the 43 major canal systems in the Indus Basin, and features largely in the DLR's operations.

To select land for reclamation, the Directorate relies on visual surveys of salinity levels carried out by field staff each year in farmers' fields. The visual survey appears to be a quick and cost-effective method, but its use as the sole selection criterion leads to questionable results. When IIMI carried out a soil-sampling exercise, the results of the analysis bore little resemblance to those obtained visually by the DLR. The Directorate has a laboratory capable of analyzing soil samples, but makes insufficient use of it at present.

Originally, reclamation operations were permitted for only two classes of land—that which had fallen into disuse within the past 5 years, and that which was 20 percent or more affected by salt. However, operations can now be extended to any land identified as affected during the visual survey. This relaxation in the rules has increased the subjectivity of decision making.

In many cases, field staff simply go through the motions of conducting the survey, making no attempt at accuracy. As a result, the DLR's time series data on salinity trends over the past 10 years are suspect. In several divisions, including the Lower Chenab East Circle, the figure for the total area affected by salinity has remained the same for several years.

More seriously still, the present selection process is open to abuse. In the absence of close supervision and technical support, field staff are easy targets for informal pressure. The study found that the process of designating land for reclamation is usually initiated by influential farmers. Most areas identified as eligible lie in the head to middle reaches of distributaries, which received 66 percent and 32 percent, respectively, of reclamation operations in 1992. Only 1 percent of operations was carried out in the tail locations, despite their greater need to combat soil salinity.

Marcel Kuper

Land reclamation activities can help push back the threat of salinity.

Because no additional water is provided to compensate for reclamation deliveries, current reclamation operations add to existing inequity in water distribution (see Box below). In one distributary, tail-end farmers desperate for water had obtained a stay order from a local court preventing further reclamation operations upstream. By forcing tail-end farmers to use still more poor-quality groundwater, current reclamation operations may even be exacerbating the very problem they are supposed to cure.

ILLUSORY EQUITY

According to DLR regulations, water provided for reclamation in a given distributary should be supplied over and above the amounts allocated for crop production. Indeed, a certificate issued by an executive officer of the Irrigation Department stating that there will be no shortage of supplies to the tail of the distributary is a required step in the approval process. There is a general belief in both the Department and the DLR that this condition is met.

IIMI's researchers found otherwise. Flow gauges monitored at the heads and tails of seven distributaries indicated that no extra water was made available in the summer months, when reclamation outlets are operated. The result was a further decline in supplies at the tail end of the system. Figure 12 (p.27) illustrates the typical pattern.

Confronted with these results, agency staff pointed out that supplies to tails are almost always considerably less than their due share, so it is impossible to convey additional water to them unless substantially increased supplies are delivered to the head of the distributary. This is rarely possible.

Investigations on farmers' fields revealed widespread and flagrant abuse of reclamation water. The selection process has, in effect, become an unfair means of obtaining extra water for cropping, particularly of rice during *kharif* (see Box below).

GROW-MORE-RICE SHOOTS

According to DLR regulations, farmers are supposed to carry out certain field operations in preparation for reclamation of water. They should level their fields and construct levees. Affected fields should be laid out in quarter-acre plots with a watercourse in the middle.

No such special preparations were observed in IIMI's study area. Farmers were unable to point to any field arrangements that differed from those normally used for cropping.

The rotation recommended for reclamation is rice in the summer followed by berseem, fodder or gram during the winter. Crop cover during the winter months is considered essential to prevent the resurgence of salts. Green manuring with *Sesbania aculeata* is the recommended practice for restoring soil fertility and organic matter.

IIMI observed no significant differences between cropping patterns in areas under reclamation and patterns in other areas. During the summer of 1992, farmers used the extra water for crops other than for the recommended reclamation crops in about 36 percent of the area selected for reclamation in 14 sample watercourses. In the whole study area, not a single instance was reported of a fine being levied against defaulters, although this is allowed for in the regulations. Of the interviewed farmers, 20 percent agreed with the observation that additional water supplies were, in fact, being used for ordinary crop production. Many admitted obtaining reclamation water for this purpose. One farmer was even found selling reclamation water to his neighbors.

Farmers have given up using the standard local term "reclamation shoots," openly calling them "grow-more-rice shoots" instead.

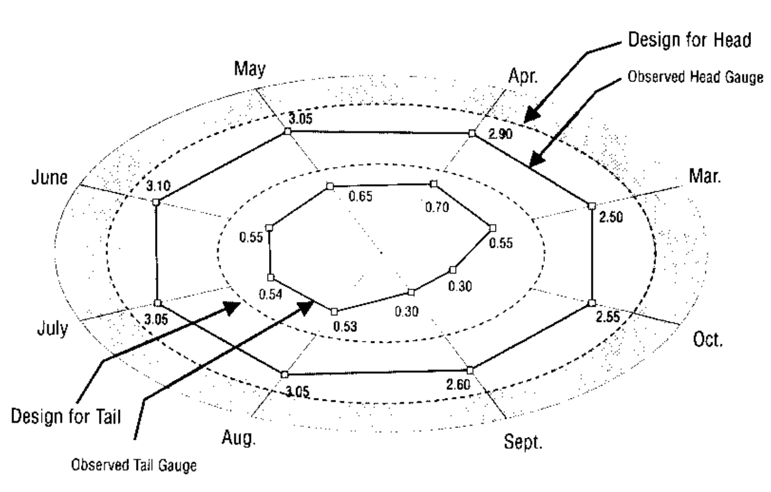
A major reason for the misuse of extra supplies is the dearth of information on the reclamation program reaching farmers, coupled with the lack of a participatory process for selecting eligible areas. In theory, a tentative proposal should be presented to farmers, inviting their applications for reclamation supplies and asking them to prepare their fields well in advance. Yet in the 20 sites where interviews were conducted, only 40 percent of the respondents acknowledged that they had received the relevant information from the DLR staff. The major source of information on reclamation operations was other farmers. Farmers were vague about who had ultimate authority and responsibility for the reclamation program.

The initiative for establishing areas for reclamation seems to come mostly from individual farmers. A great deal of follow-up is required at each stage of the cumbersome bureaucratic process required to secure approval, which spans an elaborate hierarchy of officials from the low-level reclamation *patwari*, who does the initial assessment, to the Superintending Engineer, who has the final authority. Once approval has been granted, most farmers face great difficulty in having reclamation outlets installed in time—unless, of course, they are "influential."

The DLR says it has reclaimed about 0.5 million ha since it was established. However, the procedures followed at present do not include any monitoring activity to ascertain whether reclamation operations achieve their purpose or have lasting effects. The amount of land effectively reclaimed may therefore be considerably lower. Moreover, DLR statistics also show that the area treated each year is falling, in response to a steady decline in the amount of water available for reclamation. This is estimated to have halved over the past 45 years.

The lackluster performance of the DLR is reflected in an introverted institutional culture. IIMI's study describes the DLR as isolated from other research and extension activities, and even from mainstream activities in its parent organization, the Irrigation Department. Interactions are limited mainly to the Irrigation Department staff

Figure 12. Flow gauge readings (in feet) at head and tail, Karkan Minor Distributory.



from whom the DLR must obtain the additional water supplies needed for reclamation. There are few links with other agencies.

Launched with a clear mandate and great expectations, the DLR has steadily declined in status and effectiveness. Its inadequate rules and operating procedures, established half a century ago and widely flouted today, are long overdue for reform, accompanied by a far stricter approach to enforcement (see Box below).

RECOMMENDATIONS TO THE IRRIGATION DEPARTMENT

- The present method of visual survey should be supplemented with more scientific methods, notably a soil test.
- Information on planned reclamation operations should be made freely available to all farmers in affected areas and their full participation in the decision-making process should be sought.
- More reclamation operations should be carried out in tail ends.
- The DLR should be given the necessary resources to improve its operations, particularly in monitoring and evaluation.

Cooperatives versus the Market: The Saga Scheme, Niger

In 1982, a national conference launched new policies for Niger's irrigation sector. The central plank of the reforms was a shift towards farmer management, accompanied by a change in the role of the government irrigation agency.

Despite these changes, irrigated agriculture in Niger continues to operate under difficult economic and social conditions. The Box (opposite) outlines the main institutional players and the problems they face.

THE PROTAGONISTS

Since the 1960s, government policy in Niger has required all farmers on State-sponsored irrigation schemes to organize into cooperatives. The country's cooperative movement thus did not originate at grass-roots level within the farming community, but was imposed from above by the State.

Following the 1982 conference, the government informed the cooperatives that they were to play a greater role in managing irrigation and must shoulder a higher proportion of both its operating and capital costs. Cooperatives were required to open and contribute regularly to a depreciation account with the State-run Banque du Développement de la République du Niger (BDRN). Responsibility for cooperatives passed to a newly formed government body, the Union National des Coopératives (UNC). The Union's primary role is to help cooperatives market their production, but its activities are severely hampered by the lack of funds. The Union also manages a centralized input distribution service, but this activity too is undermined by economic circumstances. For several inputs, including fertilizer, illegally imported supplies from neighboring Nigeria are often more competitively priced than its own supplies. The weakness of the Union leaves individual cooperatives without sufficient leadership, and the movement as a whole bereft of strong representation at the central government level.

The Office National des Aménagements Hydro-Agricoles (ONAHA) is the government irrigation agency. When it was formed in 1978, it had a broad mandate including all aspects of managing the country's irrigated perimeters and supplyijg inputs and services to farmers. Each perimeter had an ONAHA Director who drew up seasonal cropping calendars, set and collected users' fees and imposed sanctions against defaulters.


Prachanda Pradhan

In Niger, new policies have shifted toward farmer management.

At the 1982 conference, ONAHA's role was redefined as one of support rather than control. The organization has had difficulty in coming to terms with this change (see IIMI Annual Report 1993), but it has made a start in relinquishing its management responsibilities to the cooperatives. In theory at least, the perimeter Director now acts more as a technical advisor to the cooperative, with less direct authority than in the past. As a result of cutbacks, ONAHA's capacity to provide effective training and support services has significantly declined. The organization still hopes that, after restructuring, much of this capacity will be restored.

Riz du Niger (RINI) is the government rice-purchasing agency. It faces increasing difficulty in obtaining rice through the cooperatives, partly because it periodically offers farmers a lower price than they can obtain on the open market, and partly because it has difficulty in selling its stocks and so in paying the cooperatives on time. (The cooperatives reduce the amount paid to farmers still further, by taking a small percentage to help cover operating costs.) RINI's difficulties were eased in the short term by the 1994 devaluation of the CFA, which triggered a sharp, largely speculative, increase in demand for domestic rice. Recently, the price of imported rice has once again fallen below that of domestic rice, with the result that again RINI has a "rice mountain."

These problems add to those of the cooperatives, which complain that, since farmers no longer market enough of their produce through them, they have trouble persuading farmers to pay their fees.

Requiring farmers to shoulder the capital as well as the recurrent costs of irrigation, Niger's management transfer policy is more ambitious than that of other Sahelian countries. At present, it seems unlikely to succeed, if only because other national policies actively discourage farmers from making long-term investments.

Under Nigerien law, all land belongs to the State which expropriated farmers' plots when it developed irrigation schemes. Although previous occupants were given priority when land was reallocated following development, tenure is far from secure. Owing to the chronic weakness of Niger's financial institutions, farmers also face considerable difficulty in obtaining credit. Again, this has negative repercussions for long-term investment in the country's irrigation systems (see Box below).

CREDIT? YOU'LL BE LUCKY! SYSTEM REHABILITATION? FORGET IT!

The main suppliers of credit to Niger's farmers were the BDRN and the Caisse National de Crédit Agricole (CNCA), but these institutions went bankrupt in 1989 as large creditors defaulted on repayments following the provision of loans without sufficient collateral. Niger's remaining banks are, not unnaturally, wary of extending loans to small-scale farmers, whose assets are few and whose enterprises are risky.

The distrust is mutual. Unable to obtain credit, the small farmer is even less willing to set aside sums to cover system rehabilitation—a major function of the cooperatives. When the BDRN failed, the cooperatives' depreciation accounts were blocked. The State eventually reinstated the accounts, but only after lengthy arbitration. Understandably, when the cooperatives finally got access to their funds, most chose not to open accounts with the new financial institution that took over the BDRN. Many cooperatives are now drawing down these funds to cover operating shortfalls and emergencies. Their longer-term responsibilities for system rehabilitation will have to be met by other means—or not met at all.

The government and donors are attempting to deal with the issue of credit scarcity, so far without success.

FEE PAYMENT

A good indicator of farmers' sense of ownership of the cooperatives is the extent to which they pay their membership fees. According to ONAHA data, the range of debt repayment for 29 irrigation schemes along the River Niger covers the entire span from 0 to 100 percent, suggesting wide differences in farmers' attitudes. An important future line of research will be to look more closely at those schemes with a high level of repayment, to detect any institutional or other factors that account for their success. For those schemes with average to low repayment rates, IIMI's research has already shown that, in some cases at least, farmers are neither the only nor indeed the worst offenders (see Box below).

DEBTORS AT THE SAGA SCHEME

Fifteen kilometers downstream from Niamey on the Niger River, is the Saga perimeter, a typical medium-sized peri-urban scheme devoted mainly to rice production. The scheme is managed by a single cooperative with approximately 1,080 members. The cooperative is subdivided into seven Groupements Mutualistes de Production (GMP).

In a diagnostic survey undertaken through the Niger Irrigation Management Project, IIMI investigated the fee recovery rates of the Saga cooperative and categorized its largest debtors (those owing more than CFA 100,000, or approximately US$200). Records kept at the cooperative allowed the researchers to analyze a 5-year period from 1988 to 1992. What emerged was a depressing picture of declining rates of fee payment over time (Figure 13). The Scheme's rice yields have not fallen over the same period, so nonpayment cannot be attributed to reduced production.

Although farmers are the most numerous debtors, they are seldom the largest. In one GMP, government employees, traditional leaders and businessmen had far higher outstanding debts. In another, the biggest debtor was a retired presidential guard. And in a third, an association of veterans headed the list, with over 3 million CFA of debt.

It could be argued that the pattern of debt in a peri-urban scheme such as Saga is bound to be different to that of more rural areas. Yet initial results from other, more rural schemes where similar surveys are under way do not appear to support this argument.

The indebtedness of many of its leading members causes great difficulties for the cooperative, which is frequently unable to meet basic financial obligations such as paying its electricity bills and purchasing the inputs needed to start the next cropping season. It also sets a poor example to the rank-and-file farming members, who see no reason to pay their fees when their elders and betters do not.

Figure 13. Annual fee recovery rates for the Saga Scheme, 1988–1992.

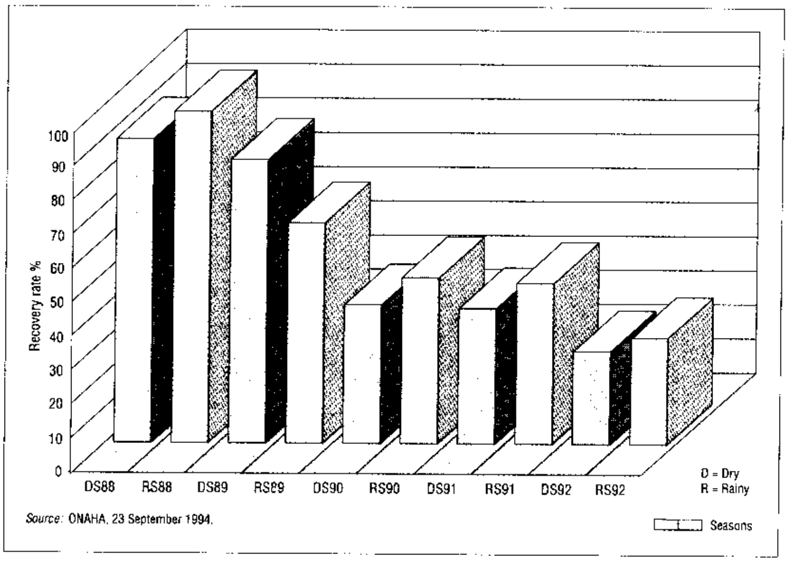
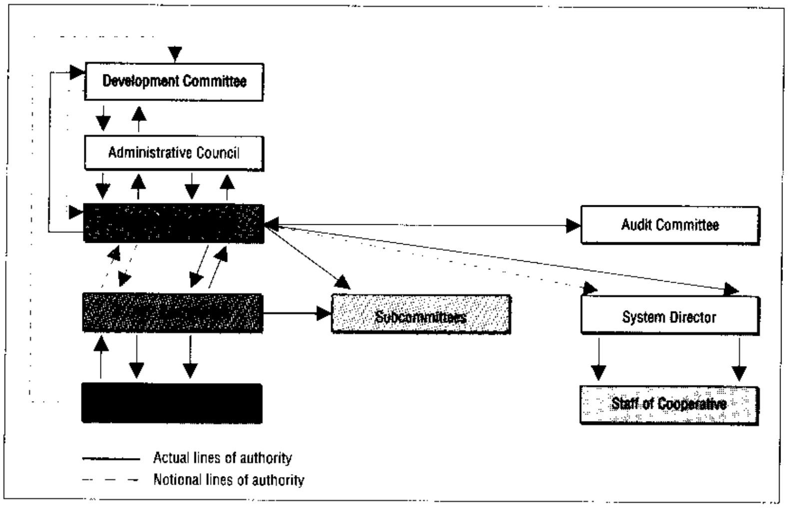


Figure 14. The structure of Saga's Irrigation Cooperative.



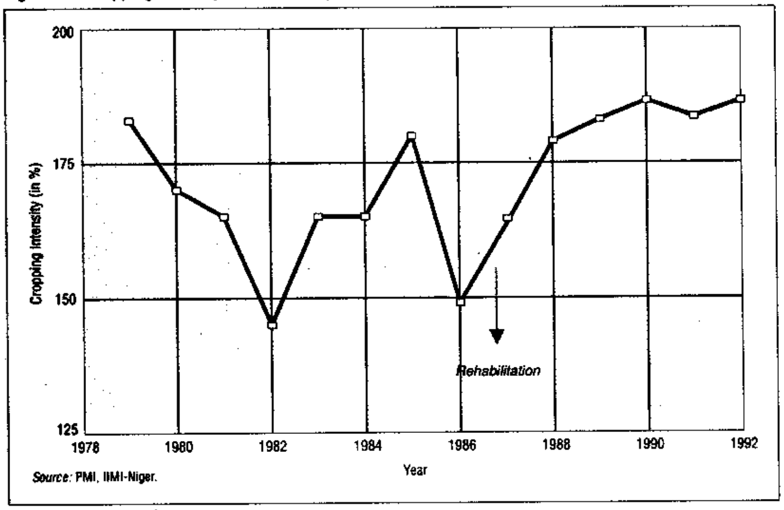
INSTITUTIONAL ISSUES

The cooperatives have an elaborate organizational structure. In the case of Saga, no less than 11 different committees meet at different levels of the hierarchy (Figure 14). To IIMI's researchers, both the Administrative Council and the Audit Committee at Saga appeared weak. Indeed, there were grounds for suspecting that the latter gave preferential treatment to influential members.

The ineffectiveness of the Audit Committee suggests that it is difficult to impose accountability on an organization that is itself an exogenous imposition on its members, especially when responsibility for this is vested in the organization alone, without support from the government. One remedy might be for the government to appoint a national supervisor of irrigation cooperatives, with a mandate to protect members' interests and legal backing to secure annual information on key financial indicators.

The democratic processes for electing committee members did not appear healthy. The members of the Development Committee and the Executive Committee are supposed

Figure 15. Cropping intensity for rice at Saga.



to be reelected every 3 years, yet there have been few changes in the composition of these committees since the cooperative was established a decade ago. The constancy of membership could, of course, be interpreted as indicating farmers' satisfaction, but indifference or a defective election process seems the more likely explanation.

Incentives and sanctions to influence members' behavior are weak or nonexistent. Denial of water to those in arrears—a sanction used in Nigeria—does not seem to be practiced in Niger. Nor are any rewards offered for speedy payment or compliance with requests. The major sanction of eviction from a holding exists in theory, but can only be effectively exercised by the civil authorities at present, since land belongs to the State and not to the cooperative. This sanction is frequently undermined by local governors when the cooperatives attempt to apply it. Despite the policy of self-management, government officials appear to have scant regard for the rights and responsibilities of cooperatives.

PERFORMANCE OF IRRIGATED AGRICULTURE

Niger's irrigated perimeters perform surprisingly well, achieving average rice yields of 9.3 t/ha/year across the country as a whole. In the case of Saga, performance appears excellent by any standard, with average annual production of unhusked rice estimated at around 12.0 t/ha. Yields have improved gradually over the years, rising by 1.2 percent a year since 1979.

Figure 15 shows the history of annual cropping intensity for rice at Saga. Since rehabilitation of the Scheme in 1987, intensity has remained stable at around 190 percent, a level so close to the Scheme's maximum potential as to suggest a high degree of motivation on the part of farmers. When non-rice crops are included the level is probably nearer 200 percent. During the dry season, many farmers cultivate fruit and vegetable crops, which may occupy as much as 10 percent of the irrigated area. As in neighboring Burkina Faso, farmers often succeed in bringing water to small enclaves within the system or to areas on the edge of it that are not officially included in the cultivable area (see IIMI Annual Report 1992).

Clearly, whatever the management problems, irrigated agriculture is a going concern in Niger.

CONCLUSIONS

The system of irrigation cooperatives introduced by the Government of Niger does not yet seem to have enlisted the full support of farmers. Without a greater sense of ownership among their members, it is difficult to see how the cooperatives can achieve financial sustainability. The government needs to take steps urgently to remove the institutional, legal and economic handicaps currently suffered by the cooperatives. Attention to issues of organizational design and to the democratic and financial accountability of the cooperatives could go some way towards solving their problems.

Production for market is catching on with farmers in Niger, particularly those near urban centers. Prices on the free market are often higher than those offered by the cooperative. Unless the cooperative system is reformed and its rights are respected, it may get left behind by events.

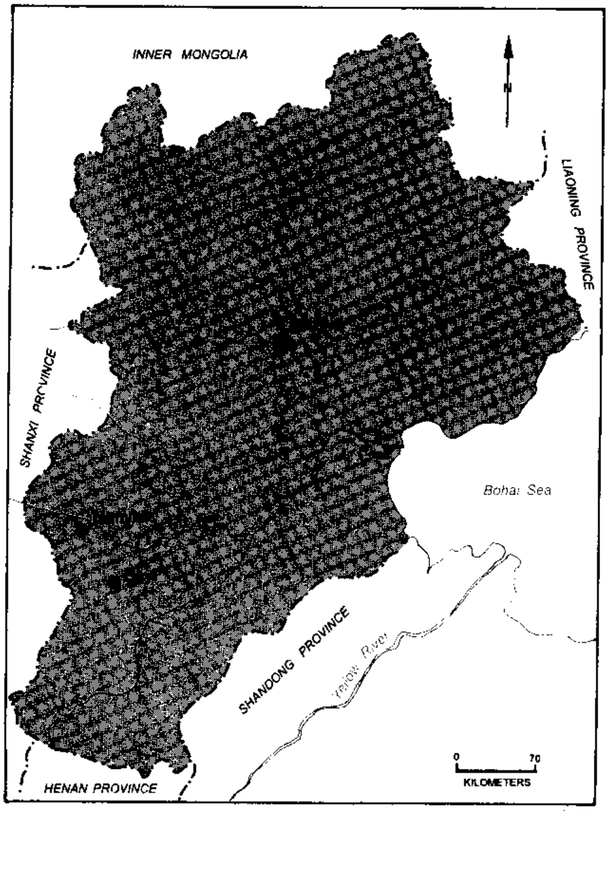
POLICIES

Reforms That Worked: Hebei Province, China

Irrigated land is vital for feeding China's huge population of 1.2 billion. Sixty-five percent of the country's food grains, 75 percent of its cash crops and 90 percent of its vegetables are produced under irrigation.

From the 1950s to the 1970s, China's irrigated area expanded rapidly as many new systems were built. Agricultural production and irrigation management were collectivized in a nationwide system of districts and communes under the leadership of Chairman Mao. By the end of this period, many irrigation systems were showing signs of structural deterioration and declining productivity as a result of poor management and maintenance. These problems were compounded by poor economic incentives for both farmers and irrigation officials.

Figure 16. Nanyao and Bayi districts, Hebei Province, China.



The post-Mao reforms of Deng Xiao Ping, in the early to mid-1980s, ushered in a new era of economic liberalization. Sweeping changes were introduced to reduce the dependence of the irrigation districts on the central government and to encourage local financial and managerial self-reliance (see Box below).

To find out more about the impact of the reforms at local level, IIMI joined forces with the Shijiazhuang Institute of Agricultural Modernization (SIAM) to conduct research on two medium-sized irrigation districts, Nanyao and Bayi, in the Hebei Province of North China (Figure 16). Nanyao District has a relatively abundant, river-based water supply and is often able to sell surplus water, whereas Bayi is water-deficit and must purchase large amounts each year.

THE REFORMS AND THEIR EFFECTS

The first package of reforms came in 1980-81, when the production responsibility system (PRS) was introduced. Under this system, long-term leases of previously communal land were allocated to individual households, which became free to organize their own production and marketing—decisions previously made by the village production team. Individual households could also retain the profits from their production. The government promoted these reforms by raising the producer price of grain by 50 percent.

Next came a general cutback in government spending. Expenditure on rural areas fell dramatically, hitting the irrigation sector particularly hard. There was a 60 percent drop in subsidies for irrigation construction.

The PRS and the hike in grain prices had the immediate effect of raising agricultural output, but the accompanying disruption of the communal system plunged the irrigation sector into turmoil. During the early 1980s there were widespread reports of conflicts over water rights and rapid deterioration of the irrigation infrastructure. The new price incentives made farmers keener to work in their fields than to contribute labor to maintenance tasks. And irrigation officials no longer had the power to make them comply with requests. Water thefts increased, as the old system of sanctions broke down. The overall result was a decline in area irrigated, which fell by nearly 1 million ha between 1979 and 1985.

A further wave of reforms quickly followed. As markets improved, the communes were seen as obstructing rather than facilitating the flow of inputs and outputs, and were consequently abolished in 1983. The work post responsibility system (WPRS), introduced as a counterpart to the agricultural PRS, provided incentives to the irrigation agency staff to increase their productivity, offering bonuses and penalties amounting to 20 percent or more of salaries. To take the place of the old communal production teams, village irrigation management groups (VIMGs) were set up. These came under village governments but were managed and financed independently.

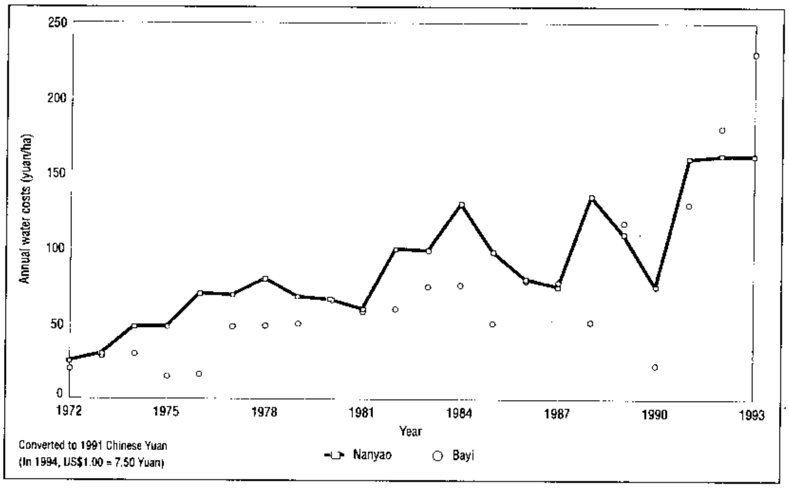
Two far-reaching reforms were introduced through national laws decreed in 1985. The first was the Regulation on Water Fees, which required users to pay for the operation and maintenance of irrigation systems. The precise level of fees could be determined locally, but the central government placed ceilings on the maximum levels. As a result, irrigation fees often fell short of real costs. In addition, the salaries of irrigation district officials had by this time fallen below those offered by alternative employers in rural China, with the result that many skilled staff were leaving the service. The second regulation was designed to combat these problems, while simultaneously increasing agricultural production. Under the Regulation on Diversified Sideline Enterprises, irrigation districts were encouraged to exploit underused land and water resources by launching additional enterprises, the profits from which could be used to cross-subsidize the costs of irrigation management. In 1988, it became official policy that no central or provincial government funds could be used for this purpose.

These reforms were variously interpreted and implemented across China, resulting in a mix of organizational arrangements. In some cases, irrigation districts are now being managed by small, locally contracted irrigation management firms. In others, the VIMGs have been strengthened to play a more central role, including fee collection, the planning and delivery of water supplies, and the organization of maintenance activities. Often, they federate to take over management at higher system levels.

The issue of financing has been central to China's process of irrigation management reform and transfer. Farmers and officials have had to come to terms with the fact that irrigation water is not a free good. When the reforms were instituted, the recovery rate of water fees at first fell drastically, reflecting confusion over managerial responsibility within irrigation systems. Since then it has made a slow but steady recovery, rising from 30 percent in 1984 to 70 percent in 1991. Improved management services and educational programs have helped to woo users into compliance with the new system.

Water fee collection rates in the two districts followed trends broadly in line with the national average. At Nanyao, the rate was 100 percent until 1984, when it fell to 85 percent following the reforms that were introduced. It continued to fall until 1991, as the district struggled with the new management system that was introduced. Only in 1993 did the rate rise over 90 percent once again. In Bayi, the collection rate plunged from 100 percent to 5 percent in 1984, but rose to 80 percent the following year and has been close to 100 percent since then.

Figure 17. Cost of irrigation water in Bayi and Nanyao districts, 1972–1993.



Both districts have introduced a system of incentives and penalties to increase fee payment rates. At Nanyao, if the VIMG collects 100 percent of the fee by the end of March, it retains 5 percent; if by the end of April, then 3 percent. If 100 percent has not been collected by May, then the VIMG must pay the amount outstanding plus a fine of an additional 3 percent. Farmers must pay their fees in advance if they are to receive water. Within limits, they can opt to pay a higher fee to obtain extra supplies. Fees are refunded if water is not delivered.

Under the provisions of the WPRS, the performance of district irrigation staff is evaluated yearly. Both districts use the same set of performance standards, which include water distribution, water use efficiency, the proportion of functional structures, fee collection rates, and the quality of maintenance work.

Through these reforms irrigation districts have become financially independent enterprises that are accountable to farmers.

Improved rates of fee collection have been achieved despite a sharp increase in the charges for water, which have been driven up by increased operations and maintenance costs (Figure 17). In Nanyao, the increase has been accompanied by a marked decline in the amount of water used. Water use per unit area today is one third of its level in the early 1980s. At Bayi, total water consumed has not declined, but the district's yields and area cultivated have both risen markedly, indicating improved water use efficiency.

Nanyao is a poorer district than Bayi, and has lagged behind its richer neighbor in implementing the reforms. Despite its water surplus, it has still not developed any sideline enterprises. Officials express a desire to make a start, but report difficulties in raising capital and getting organized. Water-deficient Bayi, in contrast, launched its first sideline enterprises as early as 1982. Its dependance on purchased water, together with the greater ability of its wealthier farmers to pay their fees, may be the driving forces behind its striking success in this area (see Box below).

SIDELINE ENTERPRISES IN BAYI DISTRICT AND HEBEI PROVINCE

Between 1984 and 1992, Bayi District's Diversified Management Division announced profits of 400,000 yuan (US$60,000). Of this, around 65 percent was plowed back into local irrigation management and infrastructure. The other 35 percent went to salaries and bonuses for staff of the Diversified Management Division, many of whom are spouses of district staff. Thus Bayi's sideline enterprises are helping to stem the flow of skilled staff out of the irrigation sector by improving their standards of living. They are also allowing the district to keep its water costs down by cross-subsidy.

Bayi District is not alone in this impressive performance. The true magnitude of the impact of the sideline enterprises reform is best appreciated when the figures for the province as a whole are considered. In 1992, the gross income from sideline enterprises in Hebei Province's Water Conservancy Bureau totaled a staggering 450 million yuan. Sixty million yuan of this was reinvested in the construction and rehabilitation of irrigation projects. Sideline enterprises also provided employment for an estimated 13,155 people.

IMPACT

Access to irrigation water has significantly altered cropping patterns in both districts. Before irrigation, in the 1950s, the main crops were maize and other spring-sown crops such as spiked millet, sweet potatoes, buckwheat and beans. Little winter wheat was grown. During the 1980s, the production of irrigated winter wheat and maize increased markedly. Recently, farmers have diversified into cash crops such as water melon, vegetables and fruit trees.

Before irrigation, most of the grain produced was consumed on the farm. In dry years, when both districts experienced a deficit, the government provided additional supplies at below-market prices. By the 1980s, farmers were selling up to a third of their wheat crop and at least one tenth of their maize. On average, farmers in Bayi now sell about 1.5 t of their grain to the government and a further 1 t at higher prices on the open market, consuming the balance of about 1.5 t at home.

Table 5 compares crop yields, input levels and net incomes for Bayi and Nanyao from the 1950s to the 1990s. Over the period as a whole, irrigation development has led to impressive gains in net incomes in both districts. The factors responsible are increased yields, facilitated by access to irrigation water, chemical fertilizers and pesticides, and new high-yielding crop varieties. Incomes at Bayi started from a higher base but grew more slowly than those at

Table 5. Value of inputs and outputs from farming in Bayi and Nanyao districts (in US$).

Item Inputs	Bayi					Nanyao				
	1950s	1960s	1970s	1980s	1990s	1950s	1960s	1970s	1980s	1990s
Chemical fertilizer		8	187.5	740	1535		8	187.5	645	1260
Pesticide			7.5	105	135			7.5	150	150
Manure[1]	30	30	45	55	55	30	30	45	75	75
Seed	150	180	200	210	390	150	180	200	210	390
Labor[2]	270	270	300	310	270	270	270	300	350	380
Machinery			10	157.5	322.5			10	150	202.5
Water fee		6	8	50	240				52.5	225
Total outputs	450	494	758	1628	2948	450	488	750	1633	2683
Average yield (t/ha)	1.05	1.6	3.6	8.8	11	0.9	1.4	3.7	7.6	7.6
Market price[3] (yuan[4]/ha)	0.66	0.87	0.67	0.58	0.69	0.66	0.87	0.67	0.58	0.69
Total	693	1392	2412	5104	7590	594	1218	2479	4408	5244
Net income	243	898	1654	3477	4643	144	730	1729	2776	2562

[1]Manure price = 1 yuan/m^3 for the 1950s, the 1960s and the 1970s; 2 yuan/m^3 for the 1980s and the 1990s.
[2]Markat price using 0.4 x wheat price + 0.6 x cotton price.
[3]Labor = 0.3 yuan/day in the 1950s and the 1960s, 0.5 yuan/day in the 1970s and 1 yuan/day in the 1980s and the 1990s.
[4]US$1.00 = 7.50 yuan in 1994.

Nanyao, which even overtook its neighbor for a brief period during the 1970s. In recent years, however, Bayi has been able to pull ahead strongly, whereas Nanyao has seen a slight decline as wheat and maize yields have stood still. Bayi's more rapid adoption of the reforms is a factor explaining its stronger performance.

CONCLUSION

China's policy reforms have undoubtedly led to more effective local management of irrigation and to increased agricultural output. However, as is typical for market-oriented reforms, the relatively wealthy appear to have gained more than the poor. A further concern is that, in poorer districts, insufficient resources are being generated to rehabilitate the country's ageing irrigation infrastructure.

EXPANDING WATER MARKETS: FORDWAH/EASTERN SADIQIA, PAKISTAN

Using irrigation water more efficiently has become a major concern for Pakistan's policymakers. The productivity of irrigated agriculture in the Indus Basin—traditionally the country's bread basket—has been declining for several years, and the region faces a growing water shortage.

Faced with inadequate and unreliable supplies of canal water, farmers resort to pumping groundwater to irrigate their crops. The region's first privately owned tubewells were installed in the 1960s. Numbers grew slowly at first, but the 1980s saw a rapid acceleration. Associated with this trend was the rise of a flourishing market in water as tubewell owners sold surplus groundwater to their neighbors.

Some donors and policymakers see promoting the further development of water markets as the best means of ensuring that water finds its way to the most efficient user. To this end, they have proposed several measures to encourage

John Colmey

Most traded water is groundwater.

the installation of tubewells. A further rapid increase in the number of tubewells has important implications for the productivity, sustainability and equity of irrigated agriculture. These implications need to be carefully assessed before any action is taken.

An important starting point is to understand how water markets actually work—who trades what sort of water with whom, at what price, and with what effect on farmers' crop production and incomes. To find out, IIMI studied markets in five sample watercourses in the Fordwah/Eastern Sadiqia Irrigation System of Southeast Punjab (see Figure 3, p.6). The watercourses lay along three distributaries located towards the tail of the system—the Fordwah and Azim distributaries of the Fordwah Branch, and the Fateh Distributary of the Malik Branch.

MARKET PROFILE

The study revealed the existence of an active and extensive water market. Table 6 shows the types of transaction encountered and the relative importance of each among the sample farmers. The different types serve different purposes: exchanges of canal water turns are intended to introduce flexibility into the otherwise rigid system of water turns practiced by farmers. Purchases of canal water and tubewell water, on the other hand, increase the total quantity of water available to farmers.

Out of 49 tubewell owners along the 5 sample watercourses, 41 sold their water. All the non-tubewell owners interviewed said that they had bought tubewell water during the previous two seasons. Sales of tubewell water were highest overall during *kharif*, when the gap between crop water requirements and canal water supplies is greatest. However, some tail watercourses had a higher level of transactions during *rabi*, when canal water is scarcer. Two electric tubewells in the command area of Fordwah 130-R were managed as commercial enterprises, being operated continuously and each selling water to more than 15 farmers. For the majority of tubewell owners, however, water marketing is not a major activity: they are farmers first of all, then water sellers.

Although most of the water traded is groundwater, canal water transactions were far from negligible. On average, 15 percent of canal water turns are exchanged or sold. Interestingly, only one farmer claimed he was selling canal water, compared with 12 saying they had bought it. Canal water sales are forbidden under the Canal and Drainage Act of 1873, and farmers are afraid of being fined. This almost certainly influenced their answers.

Table 6. Type and number of transactions per farmer, 1990–1991.

Transaction type	No. of transactions per farmer
Partial canal turn exchange	4.4
Full canal turn exchange	0.4
Tubewell water for canal water	0.6
Canal water purchased	1.2
Canal water sold	0
Tubewell water purchased	7.2
Tubewell water sold	9.4

Canal water supplies were transacted less in areas where groundwater is of poor quality. Farmers in such areas value even small amounts of good quality canal water, which they use to leach some of the salts accumulating in their soils. Tail-end farmers who sold their canal water generally did so to head-end farmers, not to their neighbors.

Analysis of the number of transactions for different farm sizes revealed that middle-sized farmers (4 to 12 ha) participate more in water markets than do small farmers and large farmers. Tubewell owners with large farms allocate most of the water they pump to their own fields, reducing the quantity available for sale. Small farmers buy more water than large farmers, but they sell much less, since fewer of them own tubewells. The farm size of tubewell owners averaged 7 ha, whereas non-tubewell owners farmed an average of only 2 ha.

The price of water varied considerably, from Rs.12 to 70 per hour (approximately US$0.38 to 2.22). Much of this variation was explained by the type of tubewell, with the lowest prices being offered by high-capacity electrically operated wells. Electric tubewell owners sold three times more hours than diesel tubewell owners and five times more than power-take-off tubewell owners. They faced lower costs for operations and maintenance and therefore charged lower prices.

Changes in water scarcity over the season or over the year are not reflected in changes in prices, as might have been expected. Nor was there any significant difference in the price between canal water and tubewell water. Canal water is of better quality, but its supply is less reliable and flexible. Nevertheless, prices are far higher—about 10 to 15 times on average—than the formal water charges levied by the Provincial Irrigation Department.

Nearly all water purchases and sales in the study area involved cash. It was only in two cases that payment was made by exchanging water for labor. Farmers did not discriminate between buyers, but they did try to keep the number of buyers low, so as to provide a reliable service. They sold most often to their close neighbors.

IMPACT

Assessing the impact of water markets on the productivity, sustainability and equity of irrigated agriculture in areas of conjunctive use is extremely complex. As a first step, farm characteristics were analyzed for three groups of farmers—tubewell owners, tubewell shareholders and tubewell water purchasers—with a view to detecting differences in cropping activity and pattern (Table 7).

Table 7. Farm characteristics of tubewell owners, shareholders and water purchasers.

Characteristics	Tubewell owner	Tubewell shareholder	Tubewell water purchaser (nonowner)
Area farmed (ha)	19	8	5
Cropping intensity (%)	171	1375	
Area under cotton (%)	69	45	51
Area under wheat (%)	68	58	52

As we have already seen, the landholdings of tubewell owners are larger than those of tubewell shareholders and non-tubewell owners—a difference which is characteristic of most irrigated areas in Pakistan. In addition, cropping intensity is higher for tubewell owners, as also are the areas under the major cash-earning crops, wheat and cotton. All three categories of farmers complement their canal supply with tubewell water, but the impact of this water is greater for tubewell owners, who have better control over the timing and amounts of applications.

Analysis of crop yields gave results that were more difficult to interpret. Tubewell owners had the highest yields of wheat, probably due to their near-perfect control of the water resource. Shareholders had surprisingly low productivity, possibly reflecting competition for water among multiple owners and other management difficulties associated with this arrangement.

Equity is often considered solely in terms of canal water supplies. IIMI's study has already demonstrated the importance of including the groundwater component in the analysis. Indeed, since conjunctive use is now widespread in the Punjab, inequity may be more closely associated with lack of access to groundwater and nonownership of a tubewell than it is with unreliable or inadequate supplies of canal water. Water markets appear to be a good means of improving the equity of access to groundwater resources, especially for small farmers who cannot invest in a tubewell.

POLICY IMPLICATIONS

The study has so far identified the following policy implications:

* The decision whether or not to promote water markets will be environment-specific. It will depend on local conditions such as water table depth, groundwater quality and canal water supply.

* Encouraging the installation of more tubewells—and especially high-capacity electric ones—will be appropriate only in areas where water tables remain relatively high and stable and groundwater is of adequate quality. Such areas are now quite rare in the Punjab, where overpumping of groundwater has become a widespread problem.

* Diesel tubewells, with their lower capacities and operating costs, represent a more attractive option than electric wells from both sustainability and equity points of

view. More farmers will be able to draw less water, spreading the benefits and reducing the environmental impact.

* Providing more reliable canal water supplies would reduce the stabilization role of private tubewells, making more tubewell water available for marketing. It would also exert a healthy downward pressure on water prices, allowing poorer farmers increased access to the market.

* As groundwater is further depleted, rights to this resource will become a more acute issue. Regulatory mechanisms will be needed to prevent overexploitation—but who will devise these and enforce compliance remain unanswered questions. To date, the monitoring of private tubewell operations is not in the mandate of any national agency or research body.

* Lifting the ban on the sale of canal water is a practical, low-cost and uncontroversial measure that could be taken without further delay. To this end, the old Canal and Drainage Act, which has been in force since 1873, will have to be revised.

Theme 4 Local Management of Irrigation

INTRODUCTION

Most governments in developing-countries have now publicly espoused a policy of turning over the management of irrigation to users. The stage of implementation reached, the process involved and its outcome all vary greatly among countries. Under the turnover component of this theme, IIMI adopts a networking approach to the study of this important subject, comparing experiences across countries and seeking to draw lessons for the many actors involved. This was the purpose of the world's first International Conference on Irrigation Management Transfer, a major event held during 1994 (see Box).

ANALYSIS AND SYNTHESIS: THE WUHAN CONFERENCE

Jointly organized by IIMI and the Wuhan University of Hydraulic and Electrical Engineering (WUHEE), the conference had over 220 participants, demonstrating the considerable interest in this subject around the world. It was hosted at Wuhan in China's Hubei Province, itself an area in the vanguard of China's successful program of irrigation management transfer.

In 18 parallel or larger plenary sessions, the participants presented and discussed over 100 papers, many of them containing important new findings. The conference thus provided a useful opportunity to analyze and synthesize experiences in different countries.

Many participants stressed that the clarity of government turnover policy and the consistency with which it is pursued are vital for success. The positive experiences of countries such as Mexico, the USA, Taiwan and New Zealand, in which all participants understood both the objectives of turnover and its implications, form a marked contrast with several African countries in which the mixed signals given by governments have led to confusion and a lack of confidence among users and agency staff.

Management transfer almost invariably requires users to pay more for their water.

Sustainable transfer programs have been achieved where governments have had the political will to deal with the negative reactions of users to rising costs. Sri Lanka provides an example of a country where this will has faltered. Schemes in China, Nepal and India demonstrate that farmers are willing to pay more when they perceive benefits proportional to their additional costs.

There are many cases in which the transfer process continues to be thwarted by bureaucratic resistance on the part of government irrigation agencies. Resistance can, however, be overcome if the agency sees reform to achieve financial autonomy as the key to its survival. Nigeria is one country in which this has occurred.

Much discussion at the conference centered around the strengthening of farmers' organizations, where the results achieved so far appear to be highly site-specific. Training and pilot schemes can prove effective, but often fail. Irrigation districts or management companies may prove a more effective model than farmers' organizations for the transfer of large-scale systems. It is still unclear whether farmers' organizations can successfully federate to take over higher levels of system management. Among the forms of continuing government support to farmers' organizations ckmmonly needed after transfer is the provision of a neutral entity to conduct a financial audit.

Relatively little evidence is yet available on the impact of irrigation management transfer in developing countries. Most sources to date report positive short-term effects on the efficiency and equity of water distribution; several also indicate improvements in maintenance and the payment of fees. Major savings for governments lie in staff reductions in government agencies. Long-term effects on the viability of irrigation systems and on the environment remain unclear.

The conference demonstrated that, although valuable lessons can be drawn from individual country experiences, no single model of transfer is universally applicable. Research, accompanied by the dissemination of relevant information, will continue to be needed.

A synthesis paper, together with a volume of selected proceedings, is now available from IIMI.

Much of the world's irrigated area is, and has always been, developed and managed by farmers. The area under farmer management is currently growing rapidly and is likely to continue to do so as management turnover is implemented. The study of farmer-managed systems—how they perform and how their performance can be enhanced through government support—forms the second component of this theme. A third and closely related component is IIMI's project on gender issues in irrigation.

Our report this year covers only a tiny proportion of the many studies undertaken under the Local Management theme. We begin with experiences of turnover in Sudan, where the abrupt dismantling of a government agency provides a superficial impression of change that masks a deeper inertia. This is followed by an account of IIMI's work on the development of low-cost survey methods in Nepal, whose government faces difficulty in allocating resources to support the country's many small-scale farmer-managed systems. Next, we visit the remote Chitral District of Pakistan, whose traditional farmer-managed systems have flourished for centuries without external support. Thence to Sri Lanka, where an innovative project is adopting new approaches to the management of natural resources. Finally, a section on Irrigation and Women summarizes an important synthesis paper published during the year and describes findings in the Chhattis Mauja System of Nepal.

THE TURNOVER PROCESS

Plus Ca Change...Sudan's White Nile Pump Schemes

In 1991, the government parastatal responsible for managing Sudan's White Nile pump irrigation schemes was drastically downsized. It laid off 70 percent of its staff and relinquished control of all but 38 of its 174 schemes. The parastatal's withdrawal took the schemes' tenants by surprise. Many were unable to make alternative arrangements to ensure water deliveries in time for the next cropping season, and were forced to leave their land fallow.

The downsizing of the White Nile Agricultural Schemes Administration (WNASA) was the early work of Sudan's new Committee for the Disposition of Public Enterprises, a special body set up to oversee the dismantling of the country's parastatals as part of a policy of management turnover and privatization. On the face of it, this policy represents a radical break with a 30-year tradition of State dominance (see Box).

PRIVATIZATION IN SUDAN

The 1960s ushered in an era of State intervention in Sudan's economy. The government nationalized leading private-sector enterprises and imposed rigid controls over agriculture, regulating markets by setting fixed prices for major commodities such as cotton and wheat. In the irrigated sector, it appropriated land and water resources, created new schemes or expanded existing ones, and formed parastatal agencies to administer them. While management was placed in the hands of a parastatal under the Ministry of Agriculture, the irrigation facilities themselves came under the Ministry of Irrigation.

Each irrigation scheme operated under a so-called triple partnership between the government, the parastatals and the tenants. The government contributed the land and water, while the parastatal supplied inputs and took management decisions, specifying cropping patterns, crop rotations and even planting dates. The tenants provided labor for cultivating and harvesting, in return for which they were paid a profit. Relationships between tenants and parastatals were mediated through a tenancy contract.

Late in the 1980s, against a background of declining agricultural productivity, these policies appeared to go abruptly into reverse. The government pledged to restore markets and revive the private sector. The Economic Salvation Program of 1990-93 reaffirmed this commitment, announcing measures to remove price controls and liberalize imports. Under the program, a special high-level committee was set up to disband public-sector organizations, including the parastatals responsible for irrigation.

At the same time as it downsized WNASA, the Committee for the Disposition of Public Enterprises licensed a private-sector company, the White Nile Holding Company (WNHC), to operate those schemes whose tenants agreed to enter into partnership with it. This company took over 16 of the schemes relinquished by WNASA. A further 33 schemes, in Dueim Province, were brought under a management organization set up by the local branch of the Tenants' Union, on the initiative of sympathetic local political leaders. The fate of the remaining schemes is unclear: some are thought to lie largely abandoned; others remain functional for the time being, but with no form of management.

The partial privatization of the White Nile schemes thus allows an intriguing study of three different management models (see Box pp. 43 and 44).

THE THREE MANAGEMENT MODELS

The Company

WNHC began operations in 1991, inheriting many of the staff laid off by WNASA. Most of its schemes are devoted to cotton. The company exercised stringent criteria in choosing its schemes, selecting only those in which facilities were in good order and soils were fertile. It was not interested in schemes in areas where the Tenants' Union was strong, preferring instead to negotiate with tenants individually.

WNHC is subject to few controls and obligations. It must have the consent of tenants to enter into a partnership before taking over a scheme, but once it does so there is no formal contract with the tenants. The participation of tenants in management is limited to representation on production and advisory committees. Company accounts are not disclosed to tenants, and there are no legal provisions compelling the company to make public its accounts. Nor is the company obliged to undertake long-term rehabilitation of its schemes. Indeed, it is entitled to withdraw from a scheme if it finds that major investments are required.

The company has reintroduced a sharecropping system along lines similar to those operated by WNASA. Under this system, the company provides all inputs, arranges for land preparation and harvesting, and advances a small amount of cash to farmers. After harvest, the company keeps part of the produce, equivalent to the value of the inputs supplied plus administration costs, water charges and other taxes and levies. The remainder of the harvest is shared on the basis of 60 percent to the tenants and 40 percent to the company.

This system reflects the contradictions inherent in Sudan's peculiar blend of privatization and continuing State dominance. The company operates according to commercial principles, to maximize profits, yet tenants' activities remain strictly regulated. Decisions on cropping patterns, cultivation methods and the use of inputs are all controlled by the management. This system differs little from the past: all that has changed is that control over farmers' activities is now exercised by a private company instead of a parastatal agency.

The Tenants' Organization

The Tenants' Organization oversees 33 schemes grouped into 10 units federated at provincial level. Each unit has its own Board of Directors, consisting of five elected tenant representatives and a nominee of the Tenants' Union.

Production relations are more liberal than in the other management systems. There is limited freedom in the choice of crops, but tenants can make their own financing arrangements, buy inputs on the open market, and sell their produce where and when they wish. The management can organize loans through the banks for those tenants unable to arrange their own credit.

The steps taken by the tenants at Dueim to set up their own management organization are unique. For the first time in Sudan, farmers have taken full charge of the management of their irrigation schemes. Key factors enabling them to do so were the presence of a strong local branch of the Tenants' Union and supportive political leadership. A third important factor is that the Dueim farmers are not settlers but were once freeholders of the land they now farm as tenants. They are currently campaigning for the return of their land. This is a clear example of the importance of property rights in effective management turnover.

The Dueim System represents Sudan's first real step towards fully privatized, farmer-managed irrigated agriculture. It may prove a useful model in the country's continuing search for viable forms of farmer management.

WNASA Management

Following downsizing, WNASA is expected to finance its own activities. This it attempts to do through the collection of land charges from tenants. Revenue is also generated through the supply of inputs and from the purchase of wheat from tenants at prices well below those on the open market.

The agency has not altered its basic management system. As before, it supplies all inputs on credit, recovering these in kind after harvest. The pressure to become self-financing has, however, led it to adopt cost-recovery procedures that place tenants at a disadvantage. The proportion of the crop to be retained by the agency is calculated according to prices at the time inputs are supplied. Given Sudan's high rate of inflation, the agency is able to make a substantial profit in this way.

The viability of the rump WNASA remains unclear. Downsizing was intended as a prelude to complete closure, so the agency has every incentive to succeed. Under the terms of the downsizing it was able to keep its more productive wheat schemes, giving it some advantage over the other management models.

TENANTS' OPINIONS

Table 8 summarizes the results of a survey to compare tenants' perceptions of the performance of the three management models in providing services.

WNASA tenants felt that the agency had greatly improved its performance. Its focus on a single crop (wheat), together with the reduced number of schemes served, had simplified its task. The lack of financial support from the central government and the threat of total closure seemed to have galvanized its remaining staff.

Tenants in the Dueim schemes, in contrast, reported a worsening of services. Now that State support has been withdrawn they must rely on the open market for input supplies. Because the private sector is not yet adequately developed to meet demand, shortages are rampant, especially of fuel. The tenant organization is still in its formative stages, and so it is not able to provide much assistance.

Under company management, tenants reported a marked improvement in the delivery of irrigation water and seeds. The company had carried out minor repairs to irrigation pumps and conveyance structures. It had also made an incentive payment to the officials of the Ministry of Irrigation to ensure adequate and timely supplies of water. However, the costs of services were highest under this management mode. The company applied about twice as much fertilizer to its crops as WNASA or Dueim tenants. Fifty-two percent of respondents said arrangements under the company were better than having no management at all, but the remaining 48 percent were apprehensive, especially since they had no idea of how costs were worked out.

Table 8. Efficiency of service provision under three management models.

Nature of service	Percentage of farmers reporting								
	WNHC (n = 51)			WNASA (n = 52)			DUEIM FMS (n = 57)		
	Better	Worse	No change	Better	Worse	No change	Better	Worse	No change
Seed supply	70	20	10	47	19	34	19	55	26
Timeliness of land preparation	40	60	0	88	12	0	30	70	0
Provision of machinery	60	27	13	92	2	6	17	72	11
Fertilizer supply	45	31	24	79	6	15	38	53	9
Irrigation	95	0	05	30	10	60	35	40	30

AGRICULTURAL PERFORMANCE

The different crops grown under differing agro-ecological conditions make it difficult to compare the performance of irrigated agriculture across the three models. In the 1993–94 season, the highest wheat yields were recorded in a WNASA-managed scheme, but this is not surprising since the company schemes are located in areas that are marginal for wheat. Net returns to farmers also appeared highest in WNASA schemes.

POWER AND PATRONAGE

So far, WNHC is the only private-sector company participating in the turnover of irrigation management in Sudan. A key question is why other companies have not become involved. Theoretically at least, there are no bars to their doing so, and few restrictions on their activities. The private sector has invested heavily in rain-fed agriculture since the 1950s, so why not in the irrigated sector too?

An informal survey revealed several reasons for the lack of interest. Foremost in the respondents' minds was continuing concern over government control of irrigated agriculture. The difficulty of raising funds was seen as another major constraint. Poor infrastructure in the White Nile area, heavy taxation and poor input supplies and services were also cited.

The fact is that Sudan's changes in economic policy have so far proved largely cosmetic. The private sector has not gained real autonomy. The economy continues to experience chronic shortages, hyperinflation, and prices that bear little relationship to real costs. Rigid lending conditions make it difficult to obtain financing. Taxation is still very high. And the exchange rate policy, which has been the bane of the irrigated sector and of the economy as a whole, remains in a state of flux, causing confusion in domestic markets.

Nor has the institutional framework for managing irrigation so far altered very greatly. As presently conceived, management turnover entails the transfer of responsibilities for providing support services to irrigated agriculture, but not that of irrigation management per se. The Ministry of Irrigation continues to control the basic rules under which schemes operate, as well as remaining responsible for the irrigation infrastructure.

Under these conditions, real competition is stifled. The State's continuing exercise of patronage in relation to private enterprise casts doubts on the validity of its free-market credentials. The fact that only one company is operating in the White Nile schemes constitutes a shift from State monopoly to private monopoly. It is widely suspected that the government's hidden agenda is to retain control over the means of production despite privatization.

CONCLUSIONS

Merely changing the ownership or the mode of management of an irrigation system does not necessarily result in improved performance. Many studies of the industrial and services sectors have shown that it matters little whether the ownership of an enterprise is public or private. Far more important is the economic environment in which it must operate.

To create a more dynamic irrigation sector, Sudan's government must be less half-hearted in its commitment to appropriate macro-economic and sectoral policies such as deregulation and liberalization. Only these policies will provide the conditions necessary to foster competition. In addition, the State must create a legal framework and institutions that protect the rights and interests of individual water users and the associations to which they belong. And it must offer farmers real incentives to take responsibility for irrigation management.

Irrigation management turnover is a process of radical change that transforms production relationships. Under State management, the principal objective is the provision of services, with social and welfare objectives predominating. The private sector, on the other hand, is not concerned with social welfare but with maximizing profits. A private-sector monopoly of the kind now operating in the White Nile schemes paves the way for the exploitation of tenants. It is the continuation of State dominance by other means.

FARMER MANAGEMENT

Making an Inventory: Experiences in Nepal

Farmer-managed irrigation systems tend to be many in number, small in size and widely scattered—all characteristics that discourage governments from investing in them. Even if funds are available, the problem is how to select, out of the many deserving cases, those systems that can make the best use of them.

Making an inventory is a good starting point. The inventory provides basic data on the location, type and size of systems. It should also provide the socioeconomic information needed to take decisions on resource allocations. Techniques for making inventories of this kind have improved in recent years. In the field, participatory rural-appraisal methods have lowered survey costs while increasing the relevance of the information collected. In the office, the use of a geographic information system (GIS) allows the rapid display and correlation of a wide range of biophysical and socioeconomic data.

IIMI's program in Nepal has assisted various government agencies in applying these techniques. Among them is the Water and Energy Commission Secretariat (WECS), which has carried out a district-wide inventory that has now covered 65 out of a total of 75 districts.

The efforts of IIMI and its partners have led to the development of a four-stage approach to making inventories. First comes a reconnaissance survey, in which a checklist of questions allows those systems not fulfilling basic criteria for assistance to be discarded straight away. The second stage is a more detailed survey of the remaining systems, with the objective of selecting the most promising ones for priority attention. At this stage, participatory rural-appraisal methods are used. The third stage is the presentation of results to the direct users—farmers as well as irrigation managers. Farmers are included in the audience because diagnostic research is often criticized for being "extractive"—not giving information back to those who provided it. The final stage is the establishment of a database for the selected systems, for use in planning interventions.

In 1994, two projects undertook inventories allowing this approach to be further refined. The first was a project of the Irrigation Management Systems Study Group (IMSSG) of the Institute of Agriculture and Animal Science (IAAS), which conducted an inventory in a Hill district of the Tanahu Region. The second was the District Strengthening Project, which aims to enhance the capacity of the Department of Irrigation to assist the farmer-managed sector. This project awarded contracts to conduct inventories to two consultancy groups, the Hydro-Engineering Services Group (Hydro for short) for an inventory in the Lamjung District in the Hills, and the NepalConsult group for an inventory in the Dang District of the Plains.

The inventory teams tested several improvements to the approach. The checklist was expanded to include data on gender and the environment, and to improve the coverage of water rights. A farmer was recruited to each team, with the aim of improving the quality of the data gathered and their interpretation from a farmers' perspective. On the IMSSG/IAAS team, a woman also participated, in the belief that this would help elicit more detailed socioeconomic information in general as well as improve the coverage of gender-related issues. In rural Nepal, female members of farm families are often reluctant to answer questions asked by male outsiders.

Including a farmer on the team proved a learning experience for everyone. The university-trained interviewers found that respondents were more willing to answer questions frankly when the farmer was present to explain the purpose of the survey. The farmer also helped interpret subtle nuances and attitudinal responses that might otherwise have been missed. For his part, the farmer learned to become part of a professional team, and to understand the perspectives and techniques of development-oriented diagnostic research in agriculture.

The participation of both farmers and female interviewers proved especially useful at the second stage of the inventory, involving semi-structured interviews and walk-throughs with farmer informants in the head and tail portions of each system.

The IMSSG/IAAS team attempted to use a GIS to improve its mapping. Delay in obtaining the equipment meant that only two systems could be documented in this way, but the experience was enough to show that the GIS would have been immensely beneficial to the whole exercise.

For stage three of the inventory, each team wrote a draft report of its findings and recommendations and had the reports translated into Nepali for presentation at a seminar attended by irrigation officials and farmers. The presentation by the IMSSG/IAAS team disappointed some farmer participants, since their systems were not on the priority list. This is one drawback of the current approach: interviewing farmers inevitably raises their expectations; no matter how well the farmer on the team had explained the purpose of the inventory, respondents tended to expect assistance in return for the information they had provided. Most participants appreciated the seminar and the prioritized list of systems. The Director General of the Department of Irrigation expressed great interest in the approach and an eagerness to try it out in other districts.

The IMSSG/IAAS team, with its more comprehensive and balanced membership, provided a report with more detailed information on the managerial, institutional and agricultural aspects of the systems it studied. However, data on water resources, and particularly on river flows, were lacking. The Hydro-Nepal/Consult team, with its greater strength in the "harder" irrigation disciplines, provided a more conventional consultancy report that gave fewer socioeconomic details but came straight to the point in terms of prioritizing systems on the basis of technical criteria.

CONCLUSION

The team composition and the methods used for inventories are always constrained by limited financial resources. If too much money is spent on inventories, none will be left for actual systems improvement! However, these experiences showed that the quality of the information obtained can be improved by including both "hard" and "soft" scientists on the team, and by inviting women scientists and farmers to work alongside male scientists. The use of geographic information systems and participatory rural-appraisal methods also pays handsome dividends.

If It Ain't Broke... Traditional Systems in Chitral, Pakistan

Many of the world's irrigation systems have never been under agency control but have been managed by farmers for centuries. Identifying their strengths and weaknesses could yield valuable lessons for policymakers and managers responsible for promoting the turnover of State-run systems. It could also help identify the services that will be needed by such systems after the State has withdrawn.

Late in 1990, IIMI began a diagnostic research on the little known traditional farmer-managed systems of the remote Chitral Region of Pakistan's North-West Frontier Province. The research was undertaken in collaboration with Enterprise and Development Consulting. The systems chosen for the research had to meet three criteria: they should not be new; they should not have received development assistance from the government in the past 15 years; and they should be "reasonably" accessible from Chitral Town—a requirement that had to be rather loosely interpreted in an area renowned for its severe winters and where there are few all-weather roads. Figure 3 (p.6) shows Chitral District, which is the location of the three schemes eventually selected.

The researchers began their work on each system with group meetings of villagers, including elders and those directly involved in irrigation. They then divided into two teams to study different aspects of the system, beginning with a walk along the channel accompanied by a few villagers. Subsequent days were spent in semi-structured interviews with individual households in each village of the command area.

What emerged from the research were three systems whose performance would be the envy of most farmers and managers in the large-scale, State-run systems of the neighboring Punjab. Farmers reported average crop yields nearly double those given in the government's Agricultural Statistics for Pakistan (1986). Cropping intensity approached 200 percent in two of the systems, and was 170 percent in the third (Table 9).

Apart from improved seeds and fertilizers, farmers use few modern inputs. They cultivate by bullock-drawn plow and harvest by hand. External labor is rarely hired. As one farmer explained, "When someone needs help he asks for it from his neighbors and gives them food in return."

The rudimentary nature of the farming system is matched only by that of the technology used for irrigation (see Box below). Infrastructure consists of low-cost locally available materials that are easy to repair or replace.

Table 9. Performance of irrigated agriculture in three farmer-managed systems of Chitral Region, Pakistan.

	Deh Joi	Pehlawandeh Joi	Moldeh Joi
Yield (t/ha)			
Maize	3.4	5.1	4.0
Wheat	4.0	4.0	3.7
Barley	3.4	4.0	
Pulses	1.0	0.7	3.0
Rice		4.0	3.0
Fertilizer use (kg/ha)			
Maize	20-30	20-30	20-30
Wheat	34-40	30-40	34-40
Barley		30-40	
Rice		35-38	30-40
Cropping intensity (%)	200	170	200
Average farm size (ha)	0.74	1.29	0.46

KEEPING IT SIMPLE: THE DEH JOI SYSTEM

Built more than 500 years ago, the 6-km long Deh Joi Channel traverses steeply sloping and boulder-strewn terrain to bring water from the Bakhtoli River to three villages. The villages are perched on unstable, terraced land, high above a valley alleged to have been destroyed by a huge flood around 1500 A.D. More recent floods in 1976 washed away much of the flat land along the river, once again forcing farmers up the slopes onto steeper land.

The system's headworks consist of large- to medium-sized rocks taken from the river bed. Farmers adapt the shape and size of the headworks according to need, moving the barrier upstream when river flow is low and down again when it is higher. The intake can easily be rebuilt when damaged or washed away by storms. Sluice gates near the head are made of four flat stones. They leak, but can be plugged when maximum water supplies are needed.

Also near the head is an escape sluice gate. Because of the risk of breaches or damage to the channel, irrigating at night is forbidden. The escape is opened at night, diverting water back to the river.

Throughout its length the channel is constructed of rocks and earth, using no mortar. A few retaining walls are found along reaches vulnerable to breaching. They are planted with vegetation to stabilize them. Most farmers' turnouts consist simply of direct cuts in the channel, filled with silt, sand and stones when not in use. Some outlets are made of tin, and one was a pipe. No measuring devices or regulators are used.

The low-cost, easily replaceable technology used for irrigation in the Deh Joi System is ideally suited to the valley's huge fluctuations in river flows and its precarious farming conditions.

Another remarkable feature of all three systems was their absence of formal institutions for managing irrigation. There were no committees or associations specifically devoted to operations and maintenance, which were organized entirely by village leaders. The traditional practice of employing a village watchman to patrol the system appeared to be dying out, with some possible loss in equity for tail-end farmers (see Box below). However, well-understood and long-accepted practices continue to govern farmers' group activities for both routine and emergency maintenance, with informal sanctions ensuring compliance. Minor damage is repaired by individual farmers.

OUT OF A JOB

The Deh Joi System used to have a village watchman whose job was to patrol the main irrigation channel two to four times a day, plugging leaks and adjusting the headworks as needed. These activities were especially useful to farmers in the middle and tail reaches, who would otherwise have had to perform these tasks themselves to maintain their flow of water.

The watchman was paid about 400 kg of maize each year, to which every household contributed. However, farmers reported that this arrangement came to an end about two years ago. The watchman demanded an increase in pay, but head-end farmers were unwilling to contribute more.

No alternative arrangements have yet been made. A tail-end farmer now walks up the system up to three times a day, with considerable loss of time for farming activities.

In none of the systems did there appear to be a history of conflicts among users. When disputes did arise, traditional, community-based mechanisms for negotiation and arbitration seemed able to resolve them amicably. For instance, two years previously a farmer in a system upstream from Deh Joi had tried to increase its intake of water, depriving Deh Joi of part of its supplies. Village heads in both the villages concerned had succeeded in dissuading him. If village heads are unable to settle a dispute, the courts or the local police may become involved.

Despite their evident strengths, these systems face an uncertain future. None of them offers opportunities for further expansion. This means that pressure on their resources is gradually increasing as the human population rises. Inequitable water supplies and declining water quality are already problems in some areas. And the fragile state of some channels makes them vulnerable to the severe storms to which the region is prone.

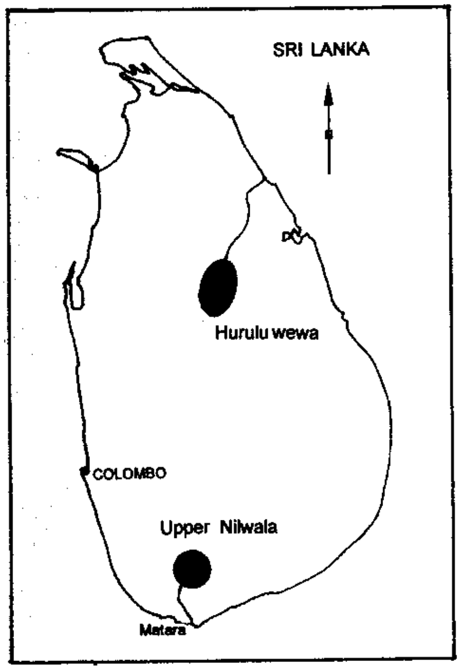
Nevertheless, the IIMI study concluded that further increases in the productivity of irrigated agriculture in the Chitral Region are more likely to come from changes in farming than in irrigation practices. This suggests a need to strengthen local extension and input supply services rather than intervening in the region's irrigation systems, which work well enough as they are. In the words of the well-known American proverb: "If it ain't broke, don't try to fix it."

SHARING CONTROL: HURULUWEWA AND NILWALA WATERSHEDS, SRI LANKA

Sri Lanka's natural resource base is under severe pressure. Rice yields have stood still or declined over the past decade. Areas cleared for tea cultivation or slash-and-burn agriculture suffer from erosion and declining soil fertility. Forest reserves are dwindling fast.

Two pilot watersheds, Huruluwewa in the dry northern zone and Nilwala in the wetter south, are the sites of an exciting new project that addresses these issues (Figure 18). The Shared Control of Natural Resources (SCOR) Project has several original features, starting with the unusually wide-ranging consultative process by which it was designed. Over a three-month period, a core group of senior politicians and managers met regularly with resource users, development banks, the business community, nongovernment organizations and local government officials to define project objectives and approaches.

Figure 18. Huruluwewa and Nilwala watersheds, Sri Lanka.



SCOR's starting point is landscape, which it aims to alter from its current undesirable state to one which resource users agree to be desirable. To do this, the project adopts a participatory group approach to planning and implementing land use on a whole watershed basis, seeking interventions that balance production and conservation objectives.

The project chose the watershed as its sphere of operations because this is a physical entity defined by an important natural resource, water, that is often scarce and must always be shared. Watersheds are divided into sub-watersheds for the purposes of project interventions. Within the watershed, the project aims to, at what it calls, "integrated water management" (see Box below).

"INTEGRATED": BUZZWORD OR BASIC PRINCIPLE?

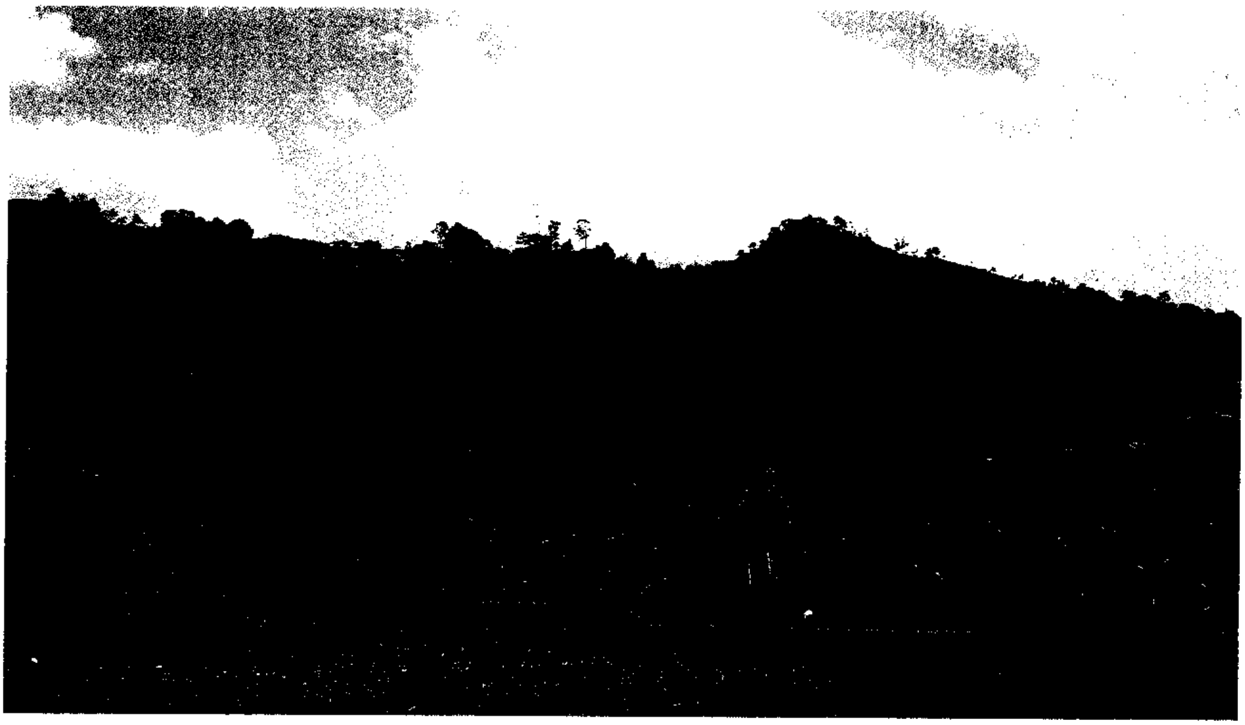
Words such as integrated are sometimes used rather loosely in development circles. For SCOR, integrated water management is a basic operating principle that has several precise meanings:

Conservation and Production

The project seeks to integrate the productive use of water with its conservation, by seeking maximum water use efficiency.

Land and Water

Land and water resources in the watershed should be managed in such a way as to enhance one another. This implies the reforestation of denuded areas, the stabilization of land subject to slash-and-burn cultivation, the



Vaseeharan Nesiah

SCOR takes a holistic approach, integrating resource management at the watershed level.

control of runoff and run in, and other interventions to conserve soil and water resources.

Upstream and Downstream

The ways in which water and land are used in the upper parts of the watershed affect users downstream. Integration means establishing appropriate hydrological, organizational and socioeconomic links between upstream and downstream areas.

Different Sources of Water

The different sources of water available in watersheds may range from rainfall, through natural streams and man-made waterways, to surface water ponds and reservoirs, and finally to groundwater tapped through wells. The efficient use of water demands that all these sources be taken into account. Exchanges between them should be planned and negotiated, rather than allowed to occur randomly.

Group action is another basic principle. The aim is to enhance individual gains through economies of scale and the benefits accruing to pooled labor and other resources. Reflecting this aim, the project has an unusual organizational structure. At grass roots level, resource users form specialized groups or companies. These can be for any purpose, such as seed multiplication, the operation of mini-hydropower plants, market gardening and so on. These groups or companies are federated at sub-watershed level, where a Council or Farmers' Organization is responsible for the overall program. A sub-watershed may have about 10 or 20 such groups.

The groups use members' inputs of labor, materials and cash to plan and implement mini-projects, each assisted with seed money from the SCOR Project, often in the form of a loan from a revolving fund and never exceeding 20 percent of the total budget. These resources are supplemented by a bank loan, which may be four to five times greater than the SCOR contribution. Whenever possible, mini-projects are linked to markets through forward contracting.

A strongly held tenet of the project is that activities should cover the entire area of a sub-watershed, not just sample plots or selected farms. The aim is not only to maximize impact but to export intervention benefits downstream. As most holdings are small, conservation practices demand group action beyond the boundaries of the individual farm if they are to be effective. For instance, contour bunds must cut across individual holdings. Adopting a model watershed approached rather than a model farm approach also has a strong demonstrative value, as project impact is more visible to outside observers. This helps spread the approach to other areas.

Work in each sub-watershed begins with the participatory appraisal and mapping of current resource use. For this purpose a group consisting of IIMI staff, local officials and resource users is formed. The group is armed with a sketch map on a scale of 1:3000, showing roads, streams and any prominent landmarks. Local resource users and officials identify holdings and site characteristics, while IIMI staff record the information and draw the map. The group is supported by a draftsman responsible for subsequent redrawing to retain accuracy to scale.

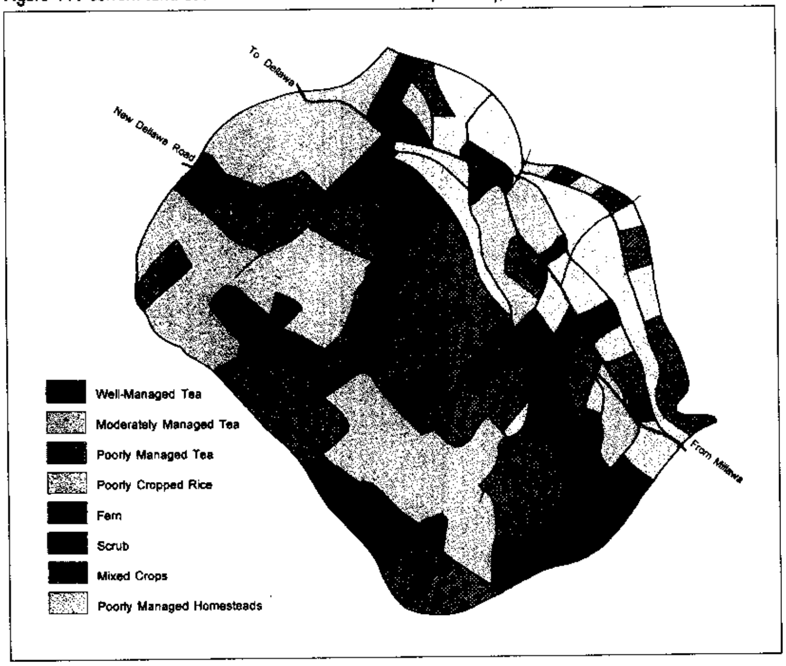
The map is then used for participatory planning in the village, helping to focus discussion on relevant resource use issues and to identify the locations where change is needed. The Box (below) describes a typical mini-project resulting from this process.

THE ANNASIDOLA MINI-PROJECT

Figures 19 and 20 illustrate actual and proposed land use before and after a mini-project for Annasidola, a sub-watershed in the Nilwala area.

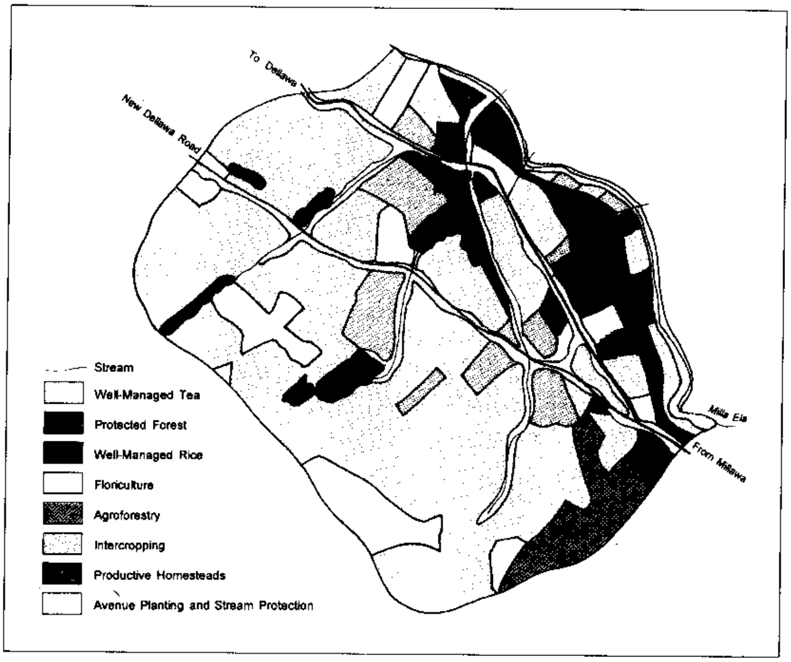
The "before" map reflects the location's deteriorating natural resource base, with a large area under moderately or poorly managed tea production, exposed waterways and degraded former forest areas on steep slopes that have been subjected to slash-and-burn cultivation. This land use pattern has triggered erosion, sedimentation, dry-season water shortages and declining water quality. The local inhabitants had realized the seriousness of their predicament before the SCOR Project arrived, and had already made some efforts to replant. The SCOR team is building on these efforts.

Figure 19. Current land use in Annasidola Sub-Watershed, January, 1994.



The "after" map portrays the possible future of the area as seen by its inhabitants. High-lying areas are densely reforested; all the tea lands are well managed; lands with fern have been converted to flower growing; unproductive rice fields have been turned into a seed farm; open forests have become agroforesty areas; and exposed streams and road reservations have been planted with avenues of trees.

Figure 20. Future land use in Annasidola Sub-Watershed.



Information on each watershed is incorporated into SCOR's spatial database, which uses a geographic information system. The management of project information follows a set of principles similar to those governing the project as a whole. The maps and the information on them are in local languages. They are owned by the participants and kept in the project area. Maps are produced for users on request, using a simple dot matrix printer. Expensive color printing is avoided.

The general land use map can be updated seasonally, providing all participants with a record of project progress. The updated map can be compared both with the baseline situation and with the ideal land use that is the mini-project's ultimate objective.

To date, the SCOR Project has made some 57 grants to mini-projects prepared by 62 resource users' groups. In all 165 groups are actively engaged in production and conservation practices.

The project is a bold and imaginative new approach to the problem of sustainable rural development. While much remains to be done, initial achievements hold out great hope for the future.

IRRIGATION AND WOMEN

The rationale for IIMI's research on gender issues in irrigation is that gender is an important but hitherto often neglected variable affecting the use of irrigation water and the efficiency of irrigated agriculture. IIMI's research on this subject began in 1992. At this early stage it is geared mainly to gathering and disseminating information, but it is likely to become more action-oriented as time goes on.

In 1994, IIMI published a major synthesis report on the current state of knowledge on gender issues in irrigation. A detailed diagnostic study of the Chhattis Mauja System in the Terai area of Nepal was also completed.

Gender Issues, Water Issues

The synthesis report, entitled *Gender Issues, Water Issues,* is based on a literature review and observations in the field. It begins with a brief account of the concepts and tools underlying gender analysis, before discussing how gender relationships may affect the outcomes of irrigation development. Several case studies drawn from the literature show how women may be adversely affected by irrigation interventions, especially the establishment of large-scale settlement schemes (see Box). The report compares findings in Asia and Africa, highlighting the influence of class and religion in the former region, and that of separate or joint male and female enterprises in the latter. A third section focuses on gender considerations relevant to irrigation management, analyzing the reasons why women have remained largely invisible in this sphere and identifying gender needs in relation to the processes, outputs and impacts of irrigation. In a final section, the report addresses phe question: how can a focus on gender contribute to improvements in the performance of irrigated agriculture?

FEMALE LABOR ON SETTLEMENT SCHEMES

Settlement schemes provide striking examples of how neglecting gender relations when planning and implementing irrigation development can negatively affect both the success of the scheme and the well-being of women.

Most settlement schemes were established to promote the production of cash crops. To achieve their ambitious production targets, the schemes had to rely on control of the labor provided by poor settler families. Free family labor was ensured by measures which made it impossible for women to cultivate their own crops, leaving them little choice but to work for their husbands. Often, only the male household heads were officially accepted as tenants for the purposes of signing the tenancy agreement, receiving inputs and services and participating in farmers' associations. Male control over the produce of female labor was further increased by the fact that irrigated crops were usually marketed exclusively through male household members.

One of the earliest descriptions of this pattern is that of the Mwea Scheme in Kenya. Here women had access to only a very small piece of land on which to grow food crops. Despite the extra labor they contributed to the rice crops of their husbands, they could make little claim on their husbands' income. While continuing to feel it was their responsibility to provide food for their families, they were reluctant to depend on their husbands either for food or for cash. They considered their husbands' contributions unreliable. Husbands often spent a considerable amount of the income from rice on beer or other individual purchases.

Another example is provided by the Mahaweli schemes in Sri Lanka, where the reduced opportunity for women to grow millet placed the poorest settler families under great stress, depriving them of a traditional subsistence crop. A study in 1986 concluded that the "chronic malnutrition in the Mahaweli H area is a direct result of planning that cuts women off from their productive resources."

How do women cope with such situations? At Mwea, one way was to sell small amounts of subsistence rice on the black market. This was not allowed under the rules of the Scheme, whose management did all it could to stop the trade. Women in the Mahaweli schemes attempted to grow as much food as they could on the small homestead plots, organizing work parties and labor exchanges to increase productivity. Some women managed to bargain with their husbands for access to a small part of the irrigated land in return for the labor they contributed to irrigated rice. Women in both schemes fell back on casual wage labor off the Scheme in neighboring villages, thereby gaining some autonomy from their husbands.

A more radical solution was simply to leave the schemes. At Mahaweli, women who became pregnant often used this as an excuse to go and stay with their mothers for a year or more. For women at both schemes, leaving often led to the break-up of their marriages.

The cases examined in the synthesis study reveal several false assumptions concerning irrigated farm families, namely that:

* Farm household resources and labor are effectively controlled and allocated by the male household head.

* Raising male farmers' incomes will benefit the whole family.

* Irrigated rice cropping is or ought to be the main or even the only income-earning and food-generating activity of households.

* The labor of wives should be confined to assisting their husbands on family fields, in addition to performing domestic or reproductive tasks.

* Farm households consist of two able-bodied adults and several children.

Instead of adapting the irrigation system to meet the needs of its users, irrigation planners typically expect families to adapt their decisions and practices to the system, so as to realize its full technical potential.

One of the points to emerge most strongly from the study is that the links between gender and irrigation development differ in different cultural, institutional and environmental contexts and according to the type of irrigation technology used. This makes them hard to foresee, with the result that attempts to devise a model or framework that can serve as an analytical or predictive tool are probably doomed to failure. For both researchers and planners, the best way of identifying gender issues in irrigation is the simple expedient of asking the people most directly concerned—female and male water users. In a 6-month case study of Nepal's Chhattis Mauja System, IIMI's researchers did just that—and came up with some surprising findings.

Getting Rid of Stereotypes: The Women of Chhattis Mauja, Nepal

Textbook feminism has it that the exclusion of women from formal decision-making bodies works to their disadvantage. IIMI's research on the Chhattis Mauja Irrigation System showed that the opposite can also be true: this system's female farmers are highly successful in getting their irrigation needs met despite, and in part because of, their nonparticipation in irrigation management organizations and activities.

Another pervasive image of rural society in developing countries is that the lives of women left behind to farm while males migrate elsewhere in search of work are harder than those in the conventional husband-and-wife farming household. Again, IIMI's research showed that this is not automatically true, although it did reveal significant inequities.

Women's and men's physical involvement in irrigated farming at Chhattis Mauja is largely a function of class. Households that can afford to do so substitute hired labor for family labor. Thus in wealthy households women receiving remittances from absent male family members often employ laborers to carry out most agricultural tasks. Alternatively, they may rent out their land to sharecroppers. Middle-class and poor households in contrast, try to maximize labor inputs by family members in order to save money (see first Box, p.56).

Individual stories provided telling evidence of how women in wealthier households had been able to free themselves from agricultural work (see second Box, p.56).

It is in the middle-class households that the physical involvement of family members in farming the household's own land is greatest. Here are found the "real farming couples," in which husband and wife work closely together and help each other in carrying out field activities. However, this class also contains a relatively high proportion of households in which women bear the main burden of responsibility for agriculture. This may be because their husbands are absent for long periods, earning a living in distant cities or a foreign country. Alternatively, their husbands may live at home but still be heavily engaged in off-farm work or

RICH AND POOR AT CHHATTIS MAUJA

Rich households (20% of total households) have access to land large enough to meet their yearly food requirements. Over half such households also have one male member or more who earn some off-farm income. Many of the men of these households had high positions in the British or Indian army before retiring to Chhattis Mauja, and still draw their army pensions. None of these households have to purchase rice, and 67 percent of them produce a marketable crop surplus, which is sold to finance the following year's agricultural inputs. Nonagricultural incomes are used for regular cash expenditures and invested in off-farm enterprises, such as small shops or buses, or in livestock.

The middle-class households (45%) depend almost entirely on farming irrigated land for their livelihood. In addition to working their smallholdings, 25 percent of these households gain access to additional land through sharecropping. Over half these families are self-sufficient in food, but only 10 percent of them produce a surplus. The income from crop surpluses is rarely enough to meet cash needs, and sometimes it is even inadequate to purchase agricultural inputs and pay labor costs. This explains why more than 50 percent of middle-class households earn some off-farm income, most often through full- or part-time employment of male members. Some of these men work as teachers, others as rickshaw pullers or in private companies in nearby towns.

Households categorized as poor (35%) own very little land and have no access to a stable off-farm income. Their holdings are too small to produce enough food to meet the family's requirements. For their livelihoods, they depend largely on sharecropping (57%) and hiring out their labor (70%). Only 8 percent of such households have off-farm employment. Many resort to irregular or illegal sources of income, such as collecting fuelwood and timber. Female household members often work as agricultural laborers.

in political and social activities. These women often experience considerable stress in carrying out farming operations in addition to their many other tasks. Many of those interviewed complained about the amount of work they have to do, often expressing a wish to give up farming altogether (see Box at bottom).

A SNAKE TOO MANY

One woman, whose husband was employed in India, recalled that she used to be responsible for carrying out all farming activities herself.

"Once my husband came over for a short visit during the paddy season," she said. "I had to irrigate a field at night, and my husband decided to accompany me. On the way to the field, he saw a snake. My husband urged us to go back home. This made him realize the hardship I had to undergo while farming. He then found a sharecropper to cultivate the field for us."

This woman was very proud, both of her husband and of the fact that she no longer had to work in the field.

LOOKING FOR A WAY OUT

During land preparation, an IIMI researcher visited a middle-class household whose senior male member is a village leader and hence heavily involved in local affairs. The husband does not earn enough income to hire laborers, so his wife organizes and carries out most agricultural tasks. She arranges exchange labor, or tries to find laborers who will accept wages in kind. That day, it had been arranged that a pair of bullocks together with their owner would come to plow their field. The husband supervised the work, and assisted by leveling part of the land and digging the field borders. The woman had arranged for the rice transplanters to arrive at 2.00 p.m. Suddenly, the husband was called away on an urgent matter by a neighbor. He left, leaving his wife no option but to complete the digging and leveling the land herself.

The start of the rice season is often an especially stressful time for middle-class women. Plowing labor and bullocks, irrigation water and transplanters all have to be organized to coincide, at a time when there is great competition for them. One woman in the village of Kalika Nagar recounted the difficulties she had experienced. Neither her husband, who is an ex-army man, nor her sons, who are at college, know how to plow. On the day she had arranged for draft animals, she could not find transplanters and had to let the bullocks go. Once she had organized transplanters, no more bullocks were left. She recounted how she had been "crying and swearing in the field," and she expressed a strong wish to rent out the land for sharecropping the following year.

Some middle-class households own their own bullocks, which they use to plow their fields and those of others. This provides either some additional income, or exchange labor for transplanting. But rearing livestock also requires considerable labor, and since it is considered female work this too increases the work load of women. As one woman put it: "Every morning, when I have to clean the shed, I am cursing my parents for not having allowed me to study, which would have enabled me to find some off-farm job."

Many other women expressed aspirations to leave agriculture, either to start their own shops and other small businesses, or else to work in a factory.

MANAGEMENT AT CHHATTIS MAUJA: NO ROOM FOR WOMEN

Many studies of farmer-managed irrigation systems claim that the latter's success is partly due to the responsiveness of the management institution to the users' needs. These studies seldom specify who the users actually are.

In principle, all irrigators at Chhattis Mauja are members of the system's General Assembly, which has final authority over management issues. In practice, however, only male irrigators are encouraged to participate in meetings. Women feel reluctant to express their needs and concerns at meetings, which are often

Chhattis Mauja's management system is three-tiered. The Executive Committee employs two *meth mukhtiyars* (main system irrigation leaders), one each for the head and tail of the system. Their tasks are to ensure effective water distribution and to organize and supervise maintenance work. Each village also has a middle-ranking *mukhtiyar,* whose task is to oversee equitable water distribution and negotiate for additional supplies when necessary. Last in the hierarchy are the irrigation messengers who assist both types of officials. Their work involves some travel at night, and is therefore deemed unsuitable for women.

In Kalika Nagar, a village near the head of the system with a high proportion of female-headed farms, a woman volunteered to become the *mukhtiyar.* She thought she would be able to perform well, since she had gained experience in organizational matters by being the local representative of the women's wing of a political party. Other villagers shared this view, and she was elected. However, she was forced to resign after only 5 months. Nobody could be found to assist her as messenger: most women did not think themselves capable; the few who did were forbidden by their husbands; and none of the men wished to work under a woman.

An important quality in a *mukhtiyar* is to be able to negotiate with the *meth mukhtiyar* and the chairman of the Executive Committee. People think that women's negotiating skills are less well developed than men's. The success of a *mukhtiyar* depends greatly on whether he has a good relationship with the chairman.

conducted in an atmosphere of hostility and mistrust.

No women hold positions on the Executive Committee responsible for operations and maintenance. Nor are any women employed as irrigation managers or messengers (see second Box, p.57).


Margreet Zwarteveen

Invisibility within the system's management structures can be an advantage.

To find out whether women's exclusion from management roles and institutions put them at a disadvantage in terms of water supplies, the IIMI researcher interviewed women farmers in two head-end villages in which they constituted a high proportion (80 percent) of the farming community. The results were surprising. One of the unwritten concepts of fairness by which the system operates is that, because women farmers experience more difficulty than men in arranging bullocks and transplanters, they should receive priority treatment when it comes to water. Accordingly, once the women are ready they inform the *mukhtiyar*. Their fields are often among the first to be irrigated.

Despite their priority treatment at planting time, women often steal water if a period of scarcity occurs later during the cropping season. In theory, they should be fined for this, but in practice few women are ever punished—they simply claim not to be aware of the rules. Their invisibility within the system's management structures makes it easier for them to avoid being taken to task. One *mukhtiyar* cited this as a good reason for increasing the involvement of women in irrigation management. *Mukhtiyars* in both villages reported that they were unable to control supplies to these villages, whose women frequently took more than their fair share of water.

Thus the women of Chhattis Mauja succeed in getting their irrigation needs met because of, rather than in spite of, their lack of participation in the institutions concerned. Not surprisingly, they show little interest in changing this situation.

At present, the inability to control water supplies to branches with a large number of women farmers is a source of irritation to the managers of Chhattis Mauja, but not a real threat to the efficiency of the irrigation system. The fact that such farmers are still in a minority overall makes it possible to grant them special favors. However, if their numbers continue to increase, this may no longer be possible (see Box, p.59).

Unlike irrigation itself, construction and maintenance remain almost exclusively male domains. The constitution of the Chhattis Mauja System explicitly rules out women from participating in such work, except at village level. The main reason for this ban is that women are considered physically less able to carry out these activities. In addition, it is not socially acceptable for women to have to work alongside strange men on such tasks. According to the men, women turning up for maintenance work would be teased.

Although women cannot provide their physical labor, it is a firm operating rule that all households must contribute to maintenance. Households headed by women must either hire male laborers to do the work, or else pay a sizable fine for noncontribution. In some households, women arrange with a male neighbor to go in their place, in return for which they work in his field. In others, women give over their land for sharecropping, making the sharecroppers responsible for their labor contribution.

A FUTURE SCENARIO

Most households in the Chhattis Mauja System are relying increasingly on off-farm work rather than on agricultural surpluses to generate household income—a trend that seems set to continue in the years ahead. As more and more men migrate in search of work, women will become increasingly responsible for farming. This tendency is reinforced by the custom of educating boys better than girls, increasing the formers' chances of escaping from the rural environment.

This outlook spells change for the Chhattis Mauja Management System. If the system is to continue to enforce the rules and regulations successfully, it will have to include women. Even the women themselves will probably begin to wish to participate once the problems caused by freeloaders and by the growing shortage of male labor for maintenance become more apparent.

In some villages, women farmers have recently won a major concession: in recognition of the difficulties they face in providing labor, they are allowed to pay only half the normal fine. In head-end villages with a high proportion of female farmers, the rule preventing their contribution to construction and maintenance is waived. However, to prevent the women from having to travel too far from home, their contribution is restricted to repairing the nearby head dam. It therefore still falls short of the amount stipulated by the system's management.

CONCLUSIONS

Including women in the management of Chhattis Mauja could improve irrigation performance. It would provide a means of regulating women's access to water and deterring water theft, especially in head-end villages. It would also help increase their labor contributions to system maintenance. In the short term at least, women see no need to increase their level of participation in the formal management system, preferring instead to rely on their current informal arrangements. However, this may change in the longer term.

AGREEMENTS AND RESEARCH CONTRACTS

Organization	Purpose
The Government of Niger	Revision of Technical Assistance Contract to extend the period of the contract by 6 months.
The Government of Nepal	Memorandum of Understanding to strengthen the efficient and effective utilization of the already developed irrigation potential in Nepal through the establishment of joint activities between relevant organizations.
Instituto Mexicano de Tecnologia Del Agua (IMTA)	To generate knowledge for improving water management in irrigated areas; to strengthen the research capacity of both institutions; to propose research projects to improve the reliability, access, equity and flexibility of water supply to users; and to increase the expertise of professionals, and officials and users' responsibility for managing, conserving and operating irrigated areas.

WORKSHOPS AND CONFERENCES ORGANIZED OR CO-ORGANIZED BY IIMI

Title	Date	Location
Workshop titled "Relations Genre et le Management de l'Irrigation"	06 Jan.	Niamey, Niger
Dutch Collaboration Project Workshop	9–13 Jan.	ILRI, the Netherlands
Muda Methodology Workshop	Jan.–Feb.	Alor Setar, Malaysia
Workshop titled "Computer-Based Decision Support Tools for Operation and Maintenance of Irrigation Systems: Pilot Activities in the Fordwah Branch Canal, Punjab" (*Co-organizers:* Irrigation Department and IIMI-Pakistan)	26 Mar.	Lahore, Pakistan
International Seminar on Geo-Synthetic Lining Systems for Irrigation Canals and Watercourses in Pakistan	27 Mar.	Lahore, Pakistan
Workshop titled "Crop-Based Irrigation Operations Study"	29 Mar.	D.I. Khan, Pakistan
DSE Workshop on Service Orientation in Irrigation	2–6 May	Feldafing, Germany
Workshop on Seasonal Planning Procedures to Improve Irrigation Management Performance: How Kirindi Oya Experience of IIMI/ID Can Be Transferred to NIRP Schemes	16 May	Irrigation Department Colombo, Sri Lanka
Session de formation des agriculteurs du périmètre de Gorgo (Training session for farmers of the Gorgo Irrigation Scheme) (*Co-organizer:* Centre régional de la promotion agro-pastorale du Centre-Est)	23–27 May	Burkina Faso
Planning Workshop for Nile Valley Regional Program Phase II	24 May– 3 June	ICARDA Cairo, Egypt
Les objectifs et les performances des petits périmètres irrigués autour des barrages (Objectives and performance of small-scale reservoir-based irrigation schemes (*Co-organizer:* Burkina Faso Ministry of Water)	08–10 June	Burkina Faso
Workshop on the Performance of the Rahad Irrigation Scheme	June	Wad Medani, Sudan
Seminar on Modernization of Irrigation Systems	06 July	Lahore, Pakistan
15th World Congress of Soil Science	10–16 July	Mexico City, Mexico
WARDA/IIMI Training Course on Irrigation Management	12 Sept.– 7 Oct.	Niamey, Niger
International Conference on Irrigation Management Transfer (*Organizers:* IIMI, WUHEE, Ford Foundation, CIDA, BMZ)	20–24 Sept.	Wuhan, China
IFPRI/DSE Sustainable Growth and Poverty Alleviation in East and Southeast Asia	3–6 Oct.	Kuala Lumpur Malaysia
Workshop on Command Water Management Processes at Hakra 6-R Distributary	13 Oct.	Lahore, Pakistan

WORKSHOPS AND CONFERENCES ORGANIZED OR CO-ORGANIZED BY IIMI (Continued)

Title	Date	Location
Workshop on Farmer Participation in Planning, Design, and Rehabilitation of NIRP Schemes: Current Status and Needed Improvements	14 Oct.	Irrigation Department Colombo, Sri Lanka
National Workshop on the Methodological Approach of the Irrigation Management Project	1–2 Nov.	Niamey, Niger
Irrigation Management Training for Kourani Baria Farmers	9–10 Nov.	Say, Saga, Niger
KOISP Impact Evaluation Study	18 Nov.	IIMI HQ, Colombo Sri Lanka
Training Course on Participatory Rural Appraisal for Irrigation Management Research	23–30 Nov.	Lahore, Pakistan
Asian Water Resources Council Meeting	24–26 Nov.	Bangkok, Thailand
1994 ITIS Network Meeting *(Organizers:* IIMI/CEMAGREF/Punjab Irrigation Department)	5–10 Dec.	Lahore, Pakistan
Annual Research and Monitoring Workshop: Fordwah/Eastern Sadiqia (South) Project	18–19 Dec.	Lahore, Pakistan

WORKSHOPS AND CONFERENCES AT WHICH IIMI WAS REPRESENTED

First Meeting of the Task Force on Sahelian Floodplains *(Organizer:* IUCN—The World Conservation Union)	4–6 Apr.	Bamako, Mali
FAO Technical Consultation on Irrigation Extension in West Africa *(Organizer:* FAO Regional Office for Africa)	5–9 Dec.	Accra, Ghana
La construction, l'utilisation et l'entretien des petits barrages (Construction, utilization and maintenance of small-scale reservoirs) *(Organizer:* United Nations Economic Commission for Africa-Multinational Programming and Operational Center [MULPOC] for West Africa)	13–16 Dec.	Ouagadougou Burkina Faso

Information

IIMI's information activities are designed to supply research findings and experience to IIMI researchers and to IIMI's partners, others operating in the field, and the wide range of people holding key positions in national irrigation management agencies and irrigation research systems.

The Information Office embraces the units of Library, Documentation, Publications (research and governance), Public Awareness, Distribution and Computer Services.

The library holdings increased by 1,554 items during 1994 bringing the total collection to 15,158 items. The new additions included 313 published monographs, 163 unpublished monographs, 511 analyticals, 565 journal articles, and 9 dissertations.

The library subscribes to 117 primary journals, 5 abstracting journals, and 12 electronic journals. The Library Catalog is maintained in the INMAGIC database and also in the micro CDS-ISIS format.

During the period under review, the special repository on irrigation management documentation was increased to 3,574 items. The CG governance collection now contains 650 items from the other CGIAR Centers.

The library and documentation section continued the Selective Dissemination of Information (SDI) service which supplies every two weeks, current literature searches to 36 institute research staff and collaborators.

The library staff actively participated in two national networks in Sri Lanka, the Agricultural Information Network (AGRINET), and the Environmental Library Network (ELINET). Information on IIMI's library holdings is sent to ELINET for inclusion in the Union Catalogue of Environmental Books. The librarian served as a resource person in an AGRINET user seminar in July, and was appointed as Training Coordinator of the AGRINET/IAALD training workshop conducted in Colombo from 15 to 20 December 1994.

The Editorial and Production Group edited, composed and published over 40 principal documents for the Institute over the last twelve months. Twenty nine of these publications were manuscripts generated by the Programs Division; 4 were governance documents including the Annual Report, IIMI Reviews, Program and Budget 1995, and the remainder comprised administrative documents for use by the Institute and the staff.

The activities in the communications program included press releases, media coverage of significant activities of the Institute, calendars, posters and video production. This section is becoming increasingly involved with design issues as part of an expanded communications effort.

This second year of replacement and upgrading of the IIMI's computer hardware proceeded according to plan allowing the installation of the LAN. During 1994, IIMI has changed its e-mail system from CGNET I to CGNET II.

Finance and Administration

In 1994, IIMI spent US$8.4 million of its income of US$9.1 million as operating expenditures (see Figures 21 and 22). Thus, the Institute ended the year with a net operating income of US$767,975 of which the allocations were US$231,529 to capital purchases and the balance US$536,446 to the operating fund, respectively. In 1994, the Institute used US$4.4 million in core unrestricted resources, US$3.1 million in core restricted support and US$1.6 million in complementary support. The Institute's unencumbered cash assets at the end of 1994 were over US$2.7 million.

In 1994, the Institute had 39 internationally recruited staff. Some 125 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 374, more than half of them based outside Sri Lanka.

CORE UNRESTRICTED, CORE RESTRICTED AND COMPLEMENTARY, 1994.

Donor		1994 Grant (US$)
CORE UNRESTRICTED		
AUSTRALIA	... ...	106,455
CIDA	... ...	236,000
EUROPEAN UNION	... ...	372,519
FORD FOUNDATION	... ...	350,000
FRANCE	... ...	129,069
GERMANY	... ...	304,967
JAPAN	... ...	364,088
THE NETHERLANDS	... ...	460,151
SPAIN	... ...	25,000
USAID	... ...	200,000
WORLD BANK	... ...	1,660,000
SUBTOTAL (UNRESTRICTED)	... ...	4,208,249
OTHER REVENUE		
BANK INTEREST	... ...	85,425
SUNDRY INCOME	... ...	79,913
REVERSAL OF PRIOR YEAR OVER PROVISION	... ...	32,822
SUBTOTAL (OTHER REVENUE)	... ...	198,160
TOTAL CORE (UNRESTRICTED RESOURCES)	... ...	4,406,409

Donor	Project		1994 Grant (US$)
RESTRICTED (CORE)			
AFDB	Support for IIMI Research Programs in Africa	... ...	5,112
CANADA	Wuhan IMT Conference	... ...	28,676
DANIDA	Health and Irrigation Study	... ...	52,784
DANIDA	Women in Irrigation	... ...	1,651
FAO	Wuhan IMT Conference	... ...	14,000
FORD	Irrigation Management for Latin America - Phase II	... ...	81,543
FORD	Wuhan IMT Conference	... ...	140,000
GERMANY	Enhancement of Research on Irrigation and Drainage Technology (IPTRID)		52,079
GERMANY	Local Managment	... ...	95,036
GERMANY	Privatization and Self-Management of Irrigation	... ...	341,002
JAPAN	Performance Assessment Program	... ...	300,000
THE NETHERLANDS	Gender Program	... ...	66,366
	SUBTOTAL	... ...	1,178,249

CORE UNRESTRICTED, CORE RESTRICTED AND COMPLEMENTARY, 1994. (Continued)

Donor	Project	1994 Grant (US$)
REDIRECTED AND RELABELED CORE		
ADB	Monitoring and Evaluation of Participatory Irrigation and Systems Management	170,932
ADB	Study on Privatization on Minor Irrigation, Bangladesh	289,196
AFDB	Irrigation Management Development in Niger	212,628
FORD	Irrigation Management for Latin America—Phase II	248,011
FORD	Support for an Irrigation Management Program in Nigeria—Phase II	97,311
FORD	Supplementary Support for Sudan	214,737
FORD	Support for Bangladesh	49,871
FORD	Turnover India Project	77,905
FORD	Water Rights Nepal	174,582
THE NETHERLANDS	Waterlogging and Salinity Project, Pakistan	112,382
USAID	Shared Control of Natural Resources (SCOR)	288,000
	Subtotal	1,935,555
	SUBTOTAL CORE RESTRICTED	3,113,804
	TOTAL CORE	7,520,213
COMPLEMENTARY		
ADB	Proposed Management Improvements to Undertake Crop-Based Irrigation Operations in NWFP, Pakistan	131,578
ADB	Sri Lanka Technical Assistance—Phase II	22,465
AFDB	Irrigation Management Development in Burkina Faso	179,807
CEC	National Irrigation Rehabilitation Project (NIRP)	301,488
FORD	Recruitment of the new Director General	40,690
GOSL	Kirindi Oya Irrigation and Settlement Project	69,558
IFAD	Participatory Rural Development Project for North Central Province	45,000
ILO	National Workshop on Nongovernmental Organizations (NGOs)	2,660
JIRCAS	Tank Cascade Systems Study	3,296
JTF	Minor Tank Rehabilitation	5,881
PAKISTAN	Fordwah Sadiqia Project	21,657
USAID	Shared Control of Natural Resources (SCOR)	695,761
USAID	Strengthening Irrigation Management in Egypt	12,070
WORLD BANK	Non-Plantation Crop Sector Improvement	15,000
WORLD BANK	National Water Management Project (NWMP)	76,302
	SUBTOTAL COMPLEMENTARY	1,623,213
	TOTAL	9,143,426

See the following table for an explanation of the projects listed above.

CONSOLIDATED STATEMENT OF FINANCIAL POSITION
AS OF 31 DECEMBER 1994 (US DOLLARS)

		Current Year 31/12/1994	Prior Year 31/12/1993
ASSETS			
Current Assets			
Cash and Cash Equivalents	... ...	2,730,362	2,487,793
Accounts Receivable:			
Donors	... ...	1,170,433	1,015,308
Employees	... ...	82,849	48,291
Others	... ...	184,941	270,922
Inventory	... ...	77,576	51,947
Prepaid Expenses	... ...	257,243	646,230
TOTAL CURRENT ASSETS	... ...	4,503,404	4,520,491
Collateral for PRI Loan	... ...	429,783	365,218
Other	... ...	Nil	3,270
Fixed Assets			
Property, Plant and Equipment	... ...	4,486,758	4,402,068
Less: Accumulated Depreciation	... ...	2,448,401	2,400,167
TOTAL FIXED ASSETS - NET	... ...	2,038,357	2,001,901
TOTAL ASSETS	... ...	6,971,544	6,890,880
LIABILITIES AND NET ASSETS			
Current Liabilities			
Contribution received in advance	... ...	1,624,456	2,024,217
Other accounts payable	... ...	657,437	932,583
Accrued expenses	... ...	67,301	51,020
TOTAL CURRENT LIABILITIES	... ...	2,349,194	3,007,820
Provision for Liabilities and Charges			
Severance/gratuity benefits	... ...	314,086	206,619
International staff repatriation	... ...	100,752	74,265
		414,838	280,884
Long-Term Debt			
PRI loan	... ...	586,484	729,481
Other	... ...	Nil	7,892
TOTAL LIABILITIES	... ...	3,350,516	4,026,077
Net Assets			
Capital Invested in Fixed Assets:			
Center-owned	... ...	1,099,693	1,027,918
In custody	... ...	238,823	116,662
Capital Fund	... ...	942,161	916,318
Operating Fund	... ...	910,568	438,687
Collateral for PRI Loan	... ...	429,783	365,218
TOTAL NET ASSETS	... ...	3,621,028	2,864,803
TOTAL LIABILITIES AND NET ASSETS	... ...	6,971,544	6,890,880

Source: 1994 Audited Accounts.

Figure 21. Income, 1984–94 (million US$).

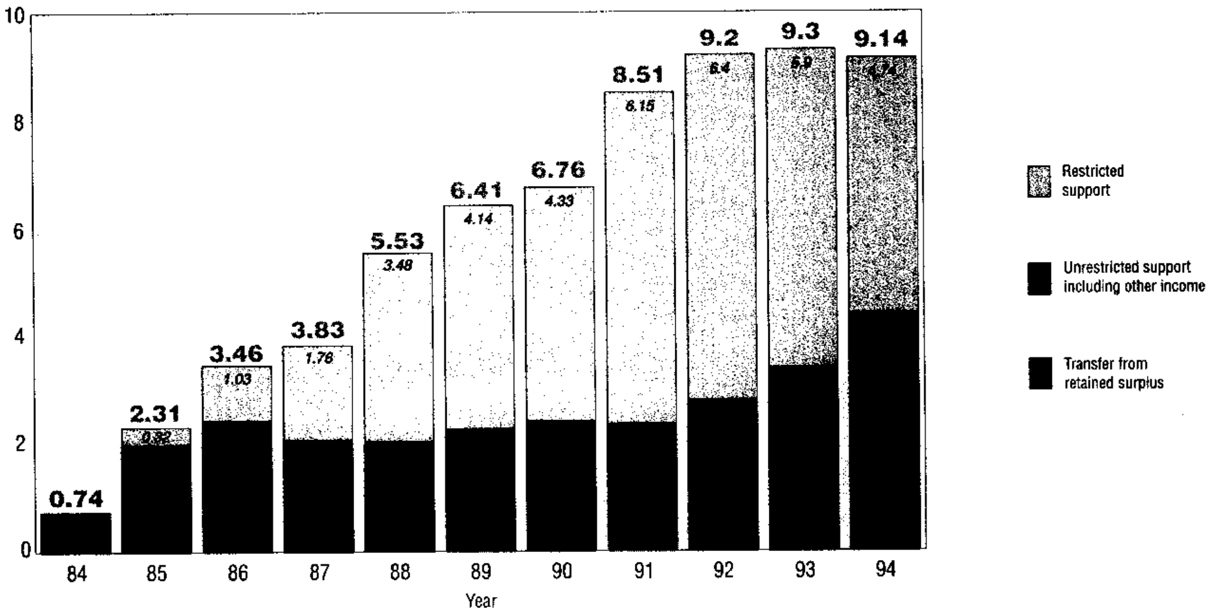
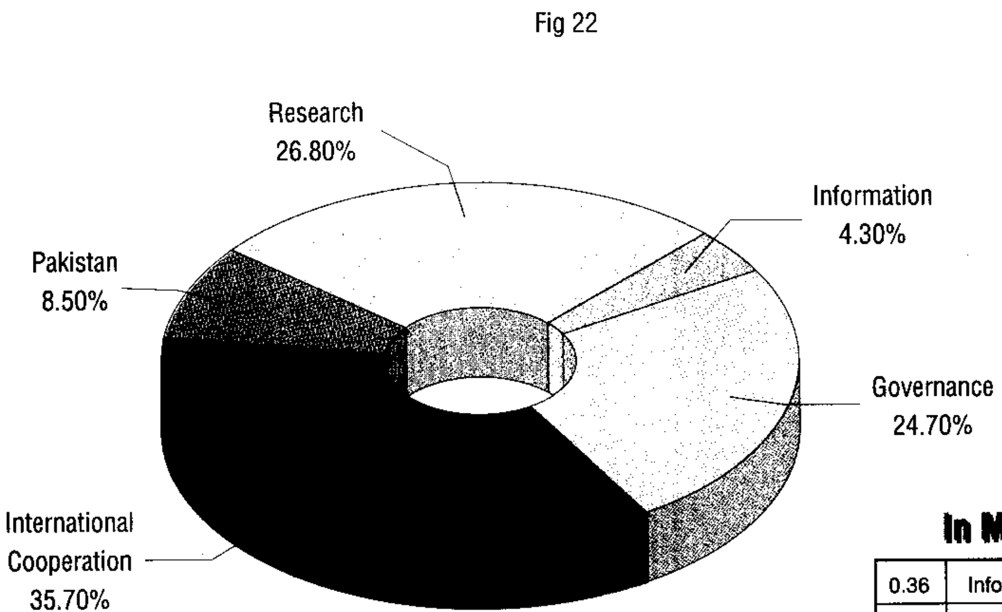


Figure 22. Net operating expenditure, 1994.



In Million US$

0.36	Information
2.07	Governance
2.99	International Cooperation
0.71	Pakistan
2.25	Research
8.38	Total

Annex I
RESTRICTED PROJECTS, 1994

Project	Donor	Pledged amount*	Duration (months)	Cumulative expenditure to 31/12/1993 (US$)	Expenditure 1994 (US$)
RESTRICTED					
Core					
SUPPORT FOR AFRICA PROGRAM Assist in financing the expenditure relating to the implementation of a program in Africa.	African Development Bank	195,112	12	190,000	5,112
INTERNATIONAL CONFERENCE ON IRRIGATION MANAGEMENT TRANSFER Support for an international conference on the transfer of irrigation management to community -based organizations.	Canadian International Development Agency	Canadian Dollars 39,000	12	Nil	28,676
	Food and Agriculture Organization	14,000	12	Nil	14,000
	Ford Foundation New York	140,000	12	Nil	140,000
GENDER ISSUES IN IRRIGATION MANAGEMENT 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; facilitate the incorporation of gender issues and analysis in ongoing IIMI activities with a view of developing a comprehensive statement on the linkages between gender issues and the performance of irrigated systems.	DANIDA	49,985	12	48,334	1,651
HEALTH AND IRRIGATION PROJECT Support to continue work initiated by JPO Mr. Flemming Konradsen with the IIMI Health and Irrigation Project.	DANIDA	86,958	12	Nil	52,784
IRRIGATION MANAGEMENT FOR LATIN AMERICA PHASE II Support for initiating 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	50,848	81,543
ENHANCEMENT OF RESEARCH ON IRRIGATION AND DRAINAGE TECHNOLOGY (IPTRID) To provide a framework for collaborative action for assessment of technology and Research and Development (R&D) needs; assist developing-countries and external supporting agencies in identifying priorities in R&D related to irrigation and drainage technology; support the formulation of R&D policies and programs in line with sectoral plans; facilitate training and exchange of information and experience.	Germany	DM 900,000	45	490,777	52,079

*In US dollars unless otherwise stated.

Annex I (Continued)

Project	Donor	Pledged amount*	Duration (months)	Cumulative expenditure to 31/12/1993 (US$)	Expenditure 1994 (US$)
Program of Support Systems for Local Management in Irrigation To define the critical elements of the necessary support system required for sustainable local management of irrigation systems.	Germany	DM 1,651,115	36	Nil	95,036
Privatization and Self-Management of Irrigation 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; develop a center of information and facilitate exchange of information among countries engaged in the turnover process.	Germany	DM 1,701,900	36	548,334	341,002
Performance Assessment Program 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 30,132,000	12	Nil	300,000
Gender Issues in Irrigation Management To increase knowledge and understanding about the relationship between gender relations and the performance of irrigation systems.	The Netherlands	Fl 300,600	24	21,093	66,366
Subtotal					**1,178,249**

Redirected and Relabeled Core

Project	Donor	Pledged amount*	Duration (months)	Cumulative expenditure to 31/12/1993 (US$)	Expenditure 1994 (US$)
Monitoring and Evaluation of Participatory Irrigation and Systems Management To assist the Government of Sri Lanka and the irrigation agencies in implementing 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	30	389,211	170,932
Study on Privatization on Minor Irrigation: Bangladesh To assist the Government of Bangladesh 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 Develoment Bank	548,000	24	75,927	289,196

*In US dollars unless otherwise stated.

ANNEX I (Continued)

Project	Donor	Pledged amount*	Duration (months)	Cumulative expenditure to 31/12/1993 (US$)	Expenditure 1994 (US$)
NIGER Performance evaluation of farmer-managed irrigation systems on the Niger River Valley.	African Development Bank	1,005,000	48	575,197	212,628
IRRIGATION MANAGEMENT FOR LATIN AMERICA PHASE II Support for initiating collaborative research and action to improve irrigation systems in Mexico and to plan similar programs throughout Latin America.	Ford Foundation New York	500,000	36	39,003	248,011
NIGERIA PHASE II Support for an irrigation management program in Nigeria	Ford Foundation New York	325,000	24	222,614	97,311
SUDAN Supplementary support for an irrigation management program in the Sudan.	Ford Foundation New York	450,000	36	219,784	214,737
BANGLADESH Partial support for an IIMI resident scientist to work on irrigation management in Bangladesh.	Ford Foundation Bangladesh	394,000	42	303,878	49,871
MONITORING AND EVALUATION OF IRRIGATION MANAGEMENT TURNOVER IN INDIA Support for a study of transfer of management authority in Indian irrigation systems.	Ford Foundation New York	230,700	36	Nil	77,905
NEPAL Support for documentation and analysis of customary and statutory water rights in Nepal.	Ford Foundation New York	200,000	24	Nil	174,582
WATERLOGGING AND SALINITY PROJECT, PAKISTAN Support to IIMI Pakistan to implement, in collaboration with national agencias, a program of applied research on waterlogging and salinity. Research will focus on irrigation strategies designed to prevent waterlogging and salinity.	The Netherlands	Fl 5,752,000	60	Nil	112,382
SHARED CONTROL OF NATURAL RESOURCES (SCOR) 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	288,000	29	Nil	288,000
SUBTOTAL					**1,935,555**
TOTAL RESTRICTED CORE GRANTS					**3,113,804**

*In US dollars unless otherwise stated.

ANNEX I (Continued)

Project	Donor	Pledged amount*	Duration (months)	Cumulative expenditure to 31/12/1993 (US$)	Expenditure 1994 (US$)
COMPLEMENTARY					
PAKISTAN To identify and assist in the implementation of proposed management imporvements to undertake crop-based irrigation operations in the North-West Frontier Province of Pakistan.	Asian Development Bank	860,000	36	728,422	131,578
SRI LANKA TA PHASE II 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	48	722,251	22,465
BURKINA FASO Program to strengthen the national 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	516,023	179,807
NATIONAL IRRIGATION REHABILITATION PROJECT (NIRP) To assist the Irrigation Department of Sri Lanka to identify research needs; to 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 Rehabilitation Management Unit (IRMU) which will contribute to the quality of planning and implementation of the Department's projects.	European Union	ECU 843,840+ SL Rupees 21,684,800	48	559,065	301,488
RECRUITMENT OF THE NEW DIRECTOR GENERAL Support to help the Institute recruit a new Director General.	Ford Foundation New York	130,000	18	Nil	40,690
KIRINDI OYA IRRIGATION AND SETTLEMENT PROJECT IMPACT ASSESSMENT STUDY (KOISP) 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 including the assessment of water quality and status of irrigation structures, their use status, soil erosion, siltation, and other irrigation-related subjects.	Sri Lanka	Rs.3,917,500 US$32,499	18	19,839	69,558
PARTICIPATORY RURAL DEVELOPMENT PROJECT FOR NORTH CENTRAL PROVINCE - INITIAL ENVIRONMENTAL EXAMINATION OF WATER DEVELOPMENT DIMENSION To provide a methodology for preliminary assessment of the water development component of the project and to prepare a detailed package of guidelines for project implementation.	IFAD Italy	45,000	12	Nil	45,000

*In US dollars unless otherwise stated.

Annex I (Continued)

Project	Donor	Pledged amount*	Duration (months)	Cumulative expenditure to 31/12/1993 (US$)	Expenditure 1994 (US$)
National Workshop on Nongovernmental Organizations (NGOs) Workshop on the role of nongovernmental organizations in irrigation development and management.	International Labour Organisation Nepal	5,951	12	Nil	2,660
Japan International Research Center for Agricultural Sciences (JIRCAS) Studies on improvement of irrigation management in minor tank cascade systems in the dry zone of Sri Lanka.	Japan	7,295	24	Nil	3,296
Minor Tank Rehabilitation Research study on costs and benefits of minor tank rehabilitation.	*Janasaviya* Trust Fund	5,881	12	Nil	5,881
Fordwah Eastern Sadiqia (South) Irrigation and Drainage Project 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.	Pakistan	123,550	12	Nil	21,657
Shared Control of Natural Resources (SCOR) 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	2,245,000	29	412,125	695,761
Strengthening Irrigation Management in Egypt To develop a plan whereby MPWWR can make effective use of IMS outputs and which would be reflected in future assistance programs and make further progress toward the establishment of a cost-recovery program needed for sustainable efficient water use and achievement of other water resource management objectives.	USAID	1,325,000	8	Nil	12,070
Non-Plantation Crop Sector Improvement - Study of Alternative Uses of Rice Lands Examine the changes in cropping patterns in the rice lands of Sri Lanka over the past decade; contrast the extent of crop diversification with expectation; compare and contrast rice with other crops with special emphasis; examine and assess the potential for expanding the cultivation of other field crops in the rice sector.	World Bank	Rs.750,000	12	Nil	15,000
Evaluation of the National Water Management Project Aims at increasing productivity and farm incomes in existing irrigation schemes through a more reliable, predictable and equitable irrigation service.	World Bank	160,000	6	Nil	76,302
Total Complementary Grants					**1,623,213**
TOTAL					**4,737,017**

*In US dollars unless otherwise stated.

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ANNEX II (Continued)

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Sri Lanka

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ANNEX III
FELLOWSHIPS AND SCHOLARSHIPS 1994

Name	Dates		Case Study	Location
			PH.D. RESEARCH FELLOWSHIPS	
Y. Dembélé	August May	1991 – 1995	Optimisation de la gestion hydraulique d'une retenue d'eau (Optimization of the hydraulic management of a reservoir) Master's Degree Research Fellowship	Burkina Faso
Salimata Ouedraogo	October December	1993 – 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
A. Hoeberichts	November July	1994 – 1995	PRA activities	Lahore-Hasilpur
J. van. Beek	December July	1993 – 1994	IMIS	Lahore-Hasilpur
F. Sannen	January August	1994 – 1994	L'incorporation du pouvoir local dans la coopérative du périmètre irrigué de Mogtédo (The role and influence of traditional power structures in the Mogtédo cooperative)	Burkina Faso
J.D. Rinaudo	May September	1994 – 1994	Water Markets	Lahore-Hasilpur
J.P. Barral	June September	1994 – 1994	Hydraulic Modeling	Pakistan/ Sri Lanka
V. Hamel	July October	1994 – 1994	Hydraulic Instrumentation	Sri Lanka
N. Rouille	July November	1994 – 1994	Collaboration on Hydraulic Model (SIC)	Lahore-Hasilpur
L.W. Seneviratne	October September	1994 – 1996	Environmental Engineering and Management	Sri Lanka

ANNEX III (Continued)

OTHER FELLOWSHIPS/INTERNSHIPS

Name	Dates		Case Study	Location
Serge Ouedraogo	March January	1993 – 1994	Contribution à l'analyse diagnostic hydraulique du périmètre irrigué de Dakiri (Contribution to the hydraulic diagnosis of the Dakiri Irrigation Scheme)	Burkina Faso
C. Mahaman	September January	1993 – 1994	Application de la télédétection à l'étude de la dégradation du bassin versant, à l'envasament 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
C.A.O Khalifa	September January	1993 – 1994	Apport de la télédétection aéro-spatiale 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
L. Sory	January April	1994 – 1995	Analyse de l'impact des systèmes de culture sur les calendriers culturaux et la gestion de l'eau (Analysis of the impact of cropping systems on crop calendars and water management)	Burkina Faso
M. Yonli	July November	1994 – 1994	Etude de réhabilitation de la station de pompage du périmètre irrigué de Savili (The rehabilitation of the pumping station of the Savili Irrigation Scheme)	Burkina Faso

Annex IV
IIMI Senior Staff 1994

Office of the Director General

Lenton, Roberto—*Argentina*
Director General

Mohtadullah, Khalid—*Pakistan*
Deputy Director General

Nugawela, D.
Executive Assistant

Finance and Administration Division

Andrews, Nancy O.—*USA*
Director, Finance and Administration

Abayasekera, M.
Manager, Travel and Conferences

Abeysekera, L.R.J.
Deputy Director, Finance and Administration

Amarasuriya, S.T.
Senior Manager, Human Resources

Bahar, T.K.O.
Personnel Officer

Buultjens, R.
Office Equipment Technician

De Silva, H.G.E.F.
Engineer, Building Services and Transport

Halvitige, G.
Senior Accountant

Joseph, H.
Executive Secretary

Samarakoon, S.M.R.
Assistant Accountant

Samaraweera, D.P.
Manager, Administrative Services

Weerasekera, S.S.
Manager, Office Support Systems

Donor Relations & Project Development Office

Fuchs-Carsch, Marian—*USA*
Head, Donor Relations & Project Development

Blok, S.
Assistant Project Development Officer

Dhanapala, K.N.
Project Development Associate

Information Office

Lenahan, James—*United Kingdom*
Head of Information

De Alwis, A.M.
Assistant Documentalist

De Silva, I.R.
Documentalist

Fernando, K.N.A.
Manager, Editorial and Production Services

Gunasekera, M.D.A.
Production Editor

Jayakody, K.
Typesetter

Karunaratne, D.C.
Artist/Cartographer

Kurukulasuriya, Kingsley
Production Editor

Nanayakkara, C.A.
Computer Services Manager

Nesiah, V.
Communications Officer

Sri-Nammuni, S.
Assistant Librarian

Sufian, A.C.M.
Production Manager

Umagiliya, N.
Writer

Van Eyck, D.
Distribution Manager

Wickremasinghe, W.M.R.K.
Electronic Technician

Yapa, N.U.
Head, Librarian

Programs Division

Research

Kijne, Jacob—*The Netherlands*
Director for Research

Abernethy, Charles—*United Kingdom*
Senior Technical Advisor
(Until 31 December 1994)

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

Gosselink, Paulus—*The Netherlands*
Associate Expert

Itakura, Jun—*Japan*
Assistant Irrigation Specialist
(Until 31 July 1994)

Johnson, Sam—*USA*
Program Leader (Local Management)
(Transferred to Mexico from 1 December 1994)

ANNEX IV (Continued)

Kato, Kazunori—*Japan*
Irrigation Specialist
(seconded through the Japanese International Cooperation Agency (JICA) (From 20 January 1994)

Kloezen, Wim—*The Netherlands*
Associate Expert
(seconded through the Ministry of Foreign Affairs, The Hague)

Konradsen, Flemming—*Denmark*
Associate Expert
(seconded through the Ministry of Foreign Affairs, DANIDA, Denmark)
(From 1 April 1994)

Merrey, Douglas—*USA*
Program Leader (Public Irrigation Organization & Sector-Level Management)

Murray-Rust, Hammond—*United Kingdom*
Senior Irrigation Specialist
(Until 24 June 1994)

Perry, Christopher—*United Kingdom*
Irrigation Specialist (seconded through the World Bank, USA)
(From 1 January 1994)

Rey, Jacques—*France*
Associate Irrigation Specialist

Vermillion, Douglas—*USA*
Irrigation Specialist

Wolter, Hans—*Germany*
Irrigation Specialist
(Seconded to IPTRID, USA)
(Until 14 April 1994).

Yashima, Shigeo—*Japan*
Irrigation Specialist

Zwarteveen, Margreet—*The Netherlands*
Associate Expert

Amarasinghe, U.A.
Research Data Analyst

Dassanaike, L.
Research Associate

de Silva, M.
Senior Secretary

Dhanasekera, D.M.
Research Officer

Ekanayake, E.M.A.
Research Officer

Fonseka, K.T.
Research Officer
(since August 1994)

Gunasinghe, L.H.R.M.
Research Officer
(until September 1994)

Hemakumara, H.M.
Senior Research Officer

Imbulana, K.A.U.S.
Research Officer

Kankanamge, A.D.H.K.
Research Officer

Priyanthi Chandrika, T.A.
Research Officer

Ratnayake, R.M.P.
Research Officer
(until January 1994)

Samad, M.
Assistant to the Director, Research

Udawatte, S.K.
Research Officer

Wanigadewa, E.Y.T.G.
Research Officer
(since October 1994)

Wasantha Kumara, W.A.U.
Research Officer

Weerakoon, K.G.P.
Research Officer

INTERNATIONAL COOPERATION / DDG'S OFFICE

Abeywickrema, Nanda—*Sri Lanka*
Director, International Cooperation
(Until 30 June 1994)

de Silva, D.
Executive Secretary

Muthukumarana, P.
Assistant to the Training Specialist

Paul, D.S.
Data Officer

Ratnayake, R.W.F.
Assistant to the Director, International Cooperation
(until February 1994)

Somasundaram, V.
Administrative Officer

VanderSay, A.
Senior Secretary

BANGLADESH

Parker, Donald—*USA*
Head, Bangladesh Field Operation
(Until 31 July 1994)

Hakim, M.A.
Researcher

Rahaman A.
Administrative Officer
(until November 1994)

Sattar, M.A.
Research Associate

BURKINA FASO

Sally, Hilmy—*Sri Lanka*
Irrigation Specialist and Project Leader

Annex IV (Continued)

Lingani, Seni
Administrative Officer

Keita, A.
Research Officer

Pouya, André Marie
Information/Communication Specialist

Yameogo, C.
Social Scientist

Mexico

Garces-Restrepo, Carlos—*Colombia*
Irrigation Management Specialist
(From 20 January 1994)

Nepal

Valera, Alfredo—*The Philippines*
Head, Nepal Field Operation
(Until 10 June 1994)

Pradhan, Ujjwal—*Nepal*
Assistant Irrigation Specialist
(Acting Head of Nepal Field Operations, effective 10 June 1994)

Durga, K.C.
Research Associate

Gurung, Juddha
Computer Associate

Shrestha, Anil
Research Associate

Niger

Lonsway, Kurt—*USA*
Irrigation Specialist and Project Leader

Abarchi, Assahaba Fatima
Sociologist

Adamou, Ekoye
Farming Systems Technician

Alhou, Issa Agali
Administrative Assistant and Accountant

Almadjir, Rabiou
Water Management Technician

Idrissa, Chipakao
Training Specialist

Maman, Chegou
Farming Systems Specialist

Moulaye, Abdou Ahmed
Water Management Specialist

Mounkaila, Issa
Training Technician

Moussa, Soussou
Agricultural Experimentation Specialist

Yadji, Guero
Soil Scientist

Pakistan

Skogerboe, Gaylord—*USA*
Director for Pakistan

Bandaragoda, D. Jayatissa—*Sri Lanka*
Senior Management Specialist

Kuper, Marcel—*The Netherlands*
Associate Expert

Strosser, Pierre—*France*
Agricultural Economist

Vander Velde, Edward J.—*USA*
Senior Irrigation Specialist
(Until July 1994)

Afaq, Rana Mohammed
Irrigation Engineer

Anwar, Haroon
General Manager, Finance and Administration
(until April)

Badruddin, M.
IIMI Pakistan Associate

Habib, Zaigham
Systems Analyst

Haider, Syed Daniyal
Accountant

Khan, Abdul Hakeem
Senior Field Research Engineer

Malik, Mohammed Saleem
Senior Field Research Social Scientist
(until November 1994)

Rehman, Gauhar
Civil Engineer (GIS Specialist)

Rehman, Saeed ur
Senior Field Research Economist

Sarwar, S.
Field Research Hydrologist

Shahid, Bagh Ali
Principal Irrigation Engineer

Wahaj, Robina
Agricultural Engineer

Zaman, uz-Waheed
Senior Field Research Engineer

Sri Lanka

Wijayaratna, C.M.—*Sri Lanka*
Head, Sri Lanka Field Operations

Brewer, Jeffrey—*USA*
Social Scientist

Haq, K.Azharul—*Bangladesh*
Technical Advisor, (NIRP)

Sakthivadivel, R.—*India*
Senior Irrigation Specialist

Abeywardene, A.
Research Officer

Aluwihare, P.B.
Research Officer
(until February 1994)

Ariyaratne, B.R.
Research Officer
(until February 1994)

Gamaathige, A.
Research Associate
(Until April 1994)

Hemakeerthi, K.A.
Research Officer
(until November 1994)

Jinapala, K.
Research Associate

Nanayakkara, Chandrasiri
Research Associate
(until February 1994)

Nandaratne, S.M.K.B.
Research Associate
(since July 1994)

Perera, L.R.
Research Officer
(until February 1994)

Ramachandran, C.
Research Officer
(since October 1994)

Ratnasiri, E.
Research Officer
(until March 1994)

Samarakoon, D.R.K.D.
Administrative Officer

Somaratne, P.G.
Research Officer
(until February 1994)

Upasena, W.J.J.
Research Officer

Withana, C.
Research Officer
(until February 1994)

SUDAN

Shafique, Muhammad S.—*Pakistan*
Head, Sudan Field Operations

Ali Dingle, Mohamed A.
Senior Economist

Gideon, Christopher
Research Assistant

Shared Control of Natural Resources Project

Adikaramge, N.K.
Acting Deputy Team Leader

Batuwitage, G.P.
Monitoring and Evaluation Specialist

Edirisinghe, E.A.P.N.
Research Officer

Ekanayake, P.S.B.
Finance Officer

Fernando, N.
Research Associate

Jayasuriya, K.N.
Enterprise Development/Marketing Specialist

Jayawardena, K.
Research Officer/Computer Analyst

Karunaratne, G.
Watershed Management Coordinator

Karunaratne, P.G.
Watershed Management Coordinator

Karunaratne, R.M.
Acting Team Leader

Kotuwegedera, J.P.K.
Research Officer

Kuruppu, W.
Watershed Management Coordinator

Medagama, J.
Team Leader
(until August 1994)

Nanayakkara, V.K.
Team Leader
(until December 1994)

Rajasekera, D.W.P.
Coordinator, Human Resources

Samarakoon Banda, J.M.
Research Associate

Samaranayake, G.
Administrative Officer

Sirimal, Bandula R.B.
Research Officer/Agricultural Economist

Tennakoon, T.M.C.K.
Organizer, Women and Youth Organizations

Upali Chandra, K.A.
Administrative Officer

Warnasuriya, T.K.
Acting Team Leader

Widanapathirana, A.S.
Research Associate
(until August 1994)

Wijenayake, D.
Watershed Management Coordinator

Annex V
CONSULTANTS 1994

Name	Country in which the Consultancy Was Conducted	Mission
Programs Division		
P.J. Farley	New Zealand	To prepare a paper about Irrigation Management Transfer on Farmer-Managed Irrigation in New Zealand.
R. Melville	Mexico	To prepare a paper about Irrigation Management Transfer on Farmer-Managed Irrigation in Mexico.
S. Mandal	Bangladesh	To prepare a paper about Irrigation Management Transfer on Farmer-Managed Irrigation in Bangladesh.
L.H. Yap-Salinas	Dominican Republic	To prepare a paper about Irrigation Management Transfer on Farmer-Managed Irrigation in the Dominican Republic.
J. Galvez-Blanco	Chile	To prepare a paper about Irrigation Management Transfer on Farmer-Managed Irrigation in Chile.
K. Nagata	Japan	To prepare a paper about Irrigation Management Transfer on Farmer-Managed Irrigation in Japan.
Marie-Pierre Fernando	Sri Lanka	To translate from French to English: a short report on Irrigation Management Transfer in Madagascar, Survey of Irrigation Management Transfer.
G. Piercy	U.S.A.	To conduct telephone interviews for a sample of 100 farmers who use water along the West Branch Canal of the Columbia Basin Project in Washington State, record the data obtained from the interviews, photocopy the completed questionnaires and submit a letter of one to two pages describing and interpreting key results and any problems encountered in the interviewing.
L. Shanan	Israel	To prepare a paper about Locally Managed Irrigation in Israel for IIMI's Short Report Series on Locally Managed Irrigation.
Kusum Athukorale	Sri Lanka	To work on research activities in Sri Lanka for the Gender Program. To participate in drafting of a working paper.
P.G. Somaratna	Sri Lanka	To assist the Associate Expert in his work in applying Participatory Rural Appraisal (PRA) tools in irrigation management research.
A. Bottrall	England	To work as the guest editor of the March 1995 Issue of Water Resources Development.
G. Sivalingam	Malaysia	To prepare a report on The Role of Farmer Organizations (Kelompoks and Mini Estates) in Improving Access to Water and Profitability: A Case Study in Muda, Malaysia.

ANNEX V (Continued)

Name	Country in which the Consultancy Was Conducted	Mission
Suellen Rinker	Sri Lanka	To assist the Research Division in facilitating Internal Program Review meetings.
M. Moench	U.S.A.	To prepare a state-of-the-art 35–40 page groundwater policy document for senior policymakers in Asia, based on the proceedings of the Workshop on Water Management.
J. A. J. Mahima	Sri Lanka	To enter maha and yala data, 1993/1994.
M. Svendsen	China	To collect remaining data (including updating existing data sets) required to complete case studies in China.
J. Oorthuizen	The Netherlands	To prepare a paper about State Disengagement and Locally Managed Irrigation in Senegal for IIMI's Short Report Series on Locally Managed Irrigation.
B. van Raamsdonk	The Netherlands	To edit the Kirindi Oya Project Impact Evaluation Study (Vol. I & II).

INFORMATION OFFICE

Name	Country in which the Consultancy Was Conducted	Mission
Pilar Garcia	Sri Lanka	To translate from Spanish to English a paper on "Traspaso De Obras De Riego En Chile."
Myriam Pikeris and Priva Schvartzman	Argentina	To translate from English to Spanish: Irrigation Management Transfer in the Columbia River Basin Project.
Consuelo Steley	Sri Lanka	To translate from English to Spanish the documents: "Development and Field-Installation of a Mathematical Simulation Model in Support of Irrigation Canal Management," and "Survey of Irrigation Management Transfer."
Marie-Pierre Fernando	Sri Lanka	To translate from English to French: the presentation on "Irrigation Management in West Africa," a report on Niger, a report on Burkina-Faso, and portions of the Madagascar FMIS Research Case Study.
S. Chater	Sri Lanka	To draft the Annual Report 1994.

OTHER DIVISIONS

Name	Country in which the Consultancy Was Conducted	Mission
Wendy Daudrumez	Sri Lanka	To update International Staff Terms and Conditions.
Frances Brody	Sri Lanka	To develop key efficiency indicators for the Institute; review budgeting and financial information systems and an option on the question of replacing the Controller; complete the budget report and cost structure analysis.

Annex V (Continued)

Name	Country in which the Consultancy Was Conducted	Mission
W. Gormbley, Jr.	Sri Lanka, U.S.A.	To review International Staff Terms and Conditions in comparison with other Centers and appropriate external organizations.
Suellen Rinker	Sri Lanka	To review current financial limits in International Staff Terms and Conditions. To assist in residential searches and for assistance in negotiation of existing lease arrangements for existing properties. To develop proposals for spouse/companion employment initiative.
F. Smith	Sri Lanka	To develop a database for a Management Information System in the Transport Unit.

International Cooperation Group

G. Karaska	Sri Lanka	To review the M&E, organization and theme actualization of the Shared Control of Natural Resources (SCOR) Project.
Sushila Rabindranath	Sri Lanka	To copyedit: Impact of PAR Workshop papers, Seasonal Report Walawe and Kirindi Oya, final draft report on the Kirindi Oya and Uda Walawe projects.
C. R. Panabokke	Sri Lanka	To provide time inputs to different projects such as SCOR, KOISP Impact Assessment, IRMU, ADB Phase II and M&E.
K. V. Raju	India	To provide assistance as required, including oversight of field data collection for India Turnover Study.
L. Weerakoon	Sri Lanka	To assist in conducting the analysis of constraints of resources use, especially in relation to forestry and agroforestry aspects.
L. R. Perera	Sri Lanka	To assist with field data collection and analysis for the Monitoring and Evaluation of Participatory Management.
B. Bagadion	Sri Lanka	To develop guidelines for financial management relevant to SCOR user organizations.
P. G. Somaratne	Sri Lanka	To assist in the Kirindi Oya Impact Assessment Study.
B. Samarasinghe	Sri Lanka	To assist in the preparation of the cost-benefit evaluation of the Kirindi Oya Impact Assessment Study.
D. M. Ariyaratna	Sri Lanka	To undertake an action research study on special SCOR interventions in the Huruluwewa feeder canal area.
J. Jayasinghe	Sri Lanka	To undertake mapping and studies in respect of Nilwala and Huruluwewa watersheds where the SCOR Project is implementing activities pertaining to natural resources management.

Annex V (Continued)

Name	Country in which the Consultancy Was Conducted	Mission
F. Marikar	Sri Lanka	To prepare background material to be presented in Morocco for the course on Policies and Strategies for Irrigated Agriculture under the auspices of the Bari Institute. To work on the Kirindi Oya Impact Assessment Project. To provide inputs to Monitoring and Evaluation of Participatory Irrigation System Management.
P. Ganewatte	Sri Lanka	To design and conduct a training for the SCOR catalyst and evaluate and report on training results and research study on land policy and land tenure.
N. U. Hemakumara	Sri Lanka	To undertake a research study on Agro-Wells and Groundwater in the Huruluwewa Watershed. To undertake baseline and monitoring and evaluation studies in relation to integrated water management in the Huruluwewa Watershed.
A. Hulugalle	Sri Lanka	To undertake a feasibility study on The production and Processing of Medicinal Plants—a component of Land and Water Conservation Efforts in the Dry Zone.
M. A. B. Anawarathna	Sri Lanka	To undertake a study on Evaluation of Profitability and Productivity of Onion, Tomato and Rice under Different Irrigation and Technology Regimes.
L. R. A. Chandrasiri	Sri Lanka	To undertake a research study on Costs and Benefits of Minor Tank Rehabilitation.
P. Pradhan	Sri Lanka	To prepare a final report on The IIMI-Nigeria Program for Submission to the Ford Foundation.
I. K. Weerawardana	Sri Lanka	To conduct an action research study on Institutional Support for Projects of Resources User Organizations.
P. B. Dharmasena	Sri Lanka	To assist and collaborate with the SCOR staff at Huruluwewa in planning and implementing programs.
P. Ganewatte	Sri Lanka	To conduct a research study on Land Policy and Land Tenure. To design and conduct a training workshop in the Huruluwewa and Nilwala watersheds and to evaluate and report on training results.
M. M. Karunanayake	Sri Lanka	To review the progress of the Shared Control of Natural Resources (SCOR) Project.

Annex V (Continued)

Name	Country in which the Consultancy Was Conducted	Mission
S.G. Narayanamoorthy	India	To collect, code and analyze bank appraisal; supervise technical reports associated with the project as well as access and analyze: the various reports produced by the Indo-Dutch Technical Assistance Team, and implementing agency reports on NWMP and O&M records. Participate in rapid survey assessment for data collection and the state-level interviews and workshops. Write-up of the data for the final report and recommendation and submitting a detailed report.
V. Rajagopalan	India	To collect, code and analyze bank appraisal; supervise technical reports associated with the project as well as access and analyze: the various reports produced by the Indo-Dutch Technical Assistance Team, implementing agency reports on NWMP and O&M records. Participate in rapid survey assessment for data collection and the state-level interviess and workshops. Write-up of the data for the final report and recommendation and submitting a detailed report.
S. Sakthi	India	To carry out field interviews in the Sathanur System—Tamil Nadu.
A.M.M. Shawkat Ali	Bangladesh	To review the analysis done to date by the BAU Bureau of Socio-Economic Research and Training (BSERT) Contract Research Team, with particular focus on the data modules related to credit.
D.W. Larson	Bangladesh	To review the analysis done to date by the BAU Bureau of Socio-Economic Research and Training (BSERT) Contract Research Team, with particular focus on the data modules related to credit.
P.M. Mane	India	To supervise process documentation data collection in Maharashtra.
S. Subramanian	India	To supervise process documentation efforts in Tamil Nadu.
L.R. Perera	Sri Lanka	To assist with field-data collection and analysis for the Monitoring and Evaluation of Participatory Management.
P.B. Aluwihare	Sri Lanka	To conduct a component of a Research Study on Potential for Diversified Cropping in the Non-Plantation Sector in Sri Lanka.
L. Amarasinghe	Sri Lanka	To conduct a special study on Minor Tank Classification of the NCP and Tank Selection for Rehabilitation.
Director, AR&TI	Sri Lanka	To conduct a process documentation research study for the Shared Control of Natural Resources Project.
K.M.P.B. Bandara	Sri Lanka	To undertake a study on Implementation of Minor Tanks for Rehabilitation with Special Reference to the North Central Province.

ANNEX V (Continued)

Name	Country in which the Consultancy Was Conducted	Mission
C.M. Madduma Bandara	Sri Lanka	To undertake an exploratory study on Eco-Tourism in Nilwala and Huruluwela watersheds.
S.H. Charles	Sri Lanka	To conduct a component of a research study on The Potential for Diversified Cropping in the Non-Plantation Sector of Sri Lanka.
K. Deheragoda	Sri Lanka	To undertake an exploratory study on Eco-Tourism in Nilwala and Huruluwewa watersheds.
V.S. Jayamanna	Sri Lanka	To conduct a research study on The Adoption of Technology in the Tea Sector in the Upper Nilwala Watershed.
M.M. Karunanayake	Sri Lanka	To review the progress of the Shared Control of Natural Resources Project.
N. Nadaraja	Sri Lanka	To conduct a special study on Minor Tank Classification of the NCP and Tank Selection for Rehabilitation.
R.M.S. Ratnayake	Sri Lanka	To conduct a special study on Minor Tank Classification of the NCP and Tank Selection for Rehabilitation.
Vice Chancellor, University of Ruhuna	Sri Lanka	To undertake a study on Crops/Livestock Yield, Profitability and Other Socioeconomic Aspects in the Nilwala Watershed.
A.G. Seneviratne	Sri Lanka	To undertake a special study on Minor Tank Classification of the NCP and Tank Selection for Rehabilitation.
S. Thiruvengadachari	India	To conduct a research study on Evaluating Satellite Remote Sensing Techniques as an Operational Tool for Monitoring and Evaluation of Irrigation Projects under NWMP in India.
P. Vitharana	Sri Lanka	To conduct a special study on Minor Tank Classification of the NCP and Tank Selection for Rehabilitation.
W.A.D. Weerasinghe	Sri Lanka	To undertake a special study on Minor Tank Classification of the NCP and Tank Selection for Rehabilitation.
D. Parker	Bangladesh	To work with BSERT team to monitor and assist in the analysis of data already collected on the computer; assist with the writing and editing of the papers being prepared for a mid-study workshop; help prepare the preliminary policy guidelines which will be derived from the analysis; help arrange the mid-study workshop and work with BSERT in planning the next phase of data collection.
University of Peradeniya	Sri Lanka	To undertake a study on Rainfall Trends, Surface Water Balance and Vegetation Change in the Huruluwewa Watershed.
K.N. Badami Ragharesh	India	To carry out field interviews in the Bhadra Command, Karnataka.
B.R. Ariyaratne	Sri Lanka	To undertake research work on Integrated Water Management and Agro-Well and Groundwater Studies at the Huruluwewa Watershed.

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 Wirtschaftliche Zusammenarbeit (Germany)
CADSWES	Center for Advanced Decision Support for Water and Environmental Systems
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 Superieurs de l'Hydraulique et de l'Equipment 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 Committee 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
IUCN	World Conservation Union
IWASARI	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
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