Conclusions

IRRIGATED NON-RICE CROPS: ASIA'S UNTAPPED RESOURCE

Throughout Asia, rice is the single largest contributor to agricultural Gross Domestic Product (GDP). It is the primary wage good, and attracts more producers and is grown over a larger total agricultural area than any other crop. Ninety percent of all rice is produced and consumed within Asia. It drives economies and sustains cultures. But all that may be changing.

Despite recent setbacks, the world market price for rice has fallen and shows few signs of reversal. Between 1981 and 1985, the price of rice in the world market fell by almost 50 percent. The drop in prices clearly reflects the dramatic success of improved rice technologies developed by the International Rice Research Institute (IRRI) and the many national rice research institutes. Once a major imported crop, most Asian countries have now achieved near self sufficiency -- Indonesia, the Philippines, Sri Lanka, India, and Thailand, among others.

According to a recent World Bank Policy Paper, partial diversification out of rice is now imperative if agriculture is to continue to play a major role in economic growth, and if rural incomes are to be sustained. Recognizing this, many Asian governments have begun to encourage or support the diversification process by promoting the production of non-rice crops in those areas and in those seasons when such crops have a comparative advantage. The greatest potential lies on well-drained soils in irrigated areas during the dry season.

But there are numerous constraints to that process. A major constraint is that most irrigation systems in Asia have been designed to grow rice during the wet season. An entire generation of irrigation engineers and irrigation managers has been trained to work within those parameters. Agricultural development policies have evolved to support rice production and marketing. Donor agencies and national governments are now turning to research and training agencies to assist in promoting the transition.

In 1985, the Asian Development Bank (ADB) and the Government of the Philippines asked IIMI to begin research in the Philippines to assist irrigation agencies in identifying constraints to producing irrigated non-rice crops during the dry season, and in finding ways to alleviate those constraints. The request followed an ADB supported study of IRRI and the International Food and Policy Research Institute (IFPRI) on "Food Demand and Supply for Developing Member Countries." That study concluded that the Philippines had a comparative advantage in the production of irrigated rice and non-rice crops.

IIMI later initiated similar projects in Sri Lanka and Indonesia; the latter project was also supported by ADB. In all three countries, IIMI has evaluated constraints, and has begun testing irrigation management innovations based on results of action research with the assistance of collaborating agencies. A full report synthesizing the results from all three countries is expected in mid-1988.

Soil moisture tests can provide useful feedback to irrigation managers.

According to Senen Miranda, IIMI irrigation engineer and co-leader of the Sri Lanka study, the research in all three countries begins with three assumptions substantiated in the project's first two years: first, water control is more demanding in terms of supply or removal of water for non-rice crops due to far stricter requirements for water -- in contrast to rice, water must be delivered intermittently and for specific periods of time. Second, irrigation systems that were designed for irrigating rice operate most efficiently under conditions of continuous flow and full supply level. Miranda says the only way that condition can be met during the dry season is by rotational distribution of the limited water supply, further complicating irrigation management.

Those two assumptions lead to a third. "Irrigating non-rice crops during the dry season requires greater management effort," says Miranda. "This can only be achieved by installing physical structures or technologies -- hardware -- or by increasing labor and managerial input -- software. The latter can come by increasing farmer participation in management or by enhancing the management capacity of agency staff."

In Sri Lanka, IIMI's field sites are located in the dry zone of the North Central Province. IIMI has chosen two irrigation systems to study: the first is the 35 year-old, 1,214 hectare (ha) Dewahuwa System, which was designed for irrigating rice during the wet season, and is managed by the Irrigation Department; the second is the Kalankuttiya Block of the Mahaweli Authority's System H, a 2,042 ha segment of a 10-year old system which was designed for irrigating rice during the wet season and non-rice crops during the dry season. Both systems are supplied by storage reservoirs. All research was carried out with the collaboration of the two governing agencies and their staffs.

Although plans for irrigating non-rice crops have been in place for over ten years in both systems, neither system has been fully successful in meeting related objectives. Crop diversification was introduced into Dewahuwa in 1975 following a Japanese-supported rehabilitation project; however, the effort was effectively in abeyance until 1984. The area cultivated since has remained well below that originally anticipated by the Japanese engineers. Likewise, although the original designers of Mahaweli System H anticipated that 60 percent of the irrigated lands would be under non-rice crops during the dry season, the actual area cultivated has been far less.

IIMI's two years of research suggest that diversified cropping has been constrained by management problems below the secondary channel level and by the lack of credit and the high risk associated with growing non-rice crops. "A major factor constraining the farmers' ability to diversify their cropping pattern," says Chris Panabokke, IIMI Agronomist and project co-leader, "is the unreliability of supply at the farm level. By that I mean the ability to feel certain that water is coming at a certain time and in a certain amount regularly. There is the further problem of how to share the water below the turnout as the data shows great variability in the amount of water going to field channels. When water is not delivered to the turnout as scheduled, there tends to be a free-for-all when it arrives."

To a certain extent, reliability is beyond the control of the agencies. At the beginning of the dry season, agencies estimate how much water has been stored and tentatively plan rotation schedules. If rain falls early in the season, water rotations are postponed to avoid over-irrigating water sensitive non-rice crops. If rain falls in mid-season or no rain falls, rotations are postponed to conserve the diminishing supply. And dry zone rainfall is extremely uncertain. Problems also arise when water schedules are changed to accommodate farmers' requests for more water. "Neither scheme," says Miranda, " has an adequate communication system to transmit scheduling changes to farmers."

David Groenfeldt, an IIMI Economic Anthropologist who leads the research on organizational aspects, believes farmers could be better organized. "There is no formal farmer organization below the secondary level in either system. Although there are farmer leaders in each system, a leader does not make a group," he contends.

"In Kalankuttiya," he says, "there is a farmer representative who is elected every three years; however, many farmers don't know who he is, and those that do know rarely communicate with him. In Dewahuwa, a farmer representative is selected by farmers to coordinate the farmers within a turnout group.

Irrigated onions in Sri Lanka. Cash inputs for non-rice crops can be three times that required for rice.

However, a turnout group can have as many as 50 farmers who may or may not be located in the turnout,* may or may not be owners of the land they cultivate, and may or may not know each other on a personal level. Farmer representatives for each turnout meet periodically with irrigation officials, but it would be inaccurate to say that they represent a group consensus among turnout farmers. The role played by farmer representatives is useful but it does not fulfill the communication needs of farmers and officials. In terms of water distribution, farmer organizations and cooperation among them can facilitate rotations, and rotations seem to be where the problems lie."

Despite these problems, farmers who do grow non-rice crops appear to do well in the head ends. "Farmers," says Panabokke, "have been obtaining yields that are about 75 percent of those achieved in Sri Lanka's research stations, which indicates adequate water supply. However, those yields drop near the tail ends of the turnouts. But in general," he continues, "Sri Lankan farmers are inclined to grow rice when there is a liberal water supply in the dry season, even though non-rice crops return greater net profits than rice."

"Growing non-rice crops is a high risk venture," says Edward Martin, an IIMI Agricultural Economist. "Cash and labor inputs can be three or four times higher for non-rice crops than for rice crops. In contrast to rice, farmers must stay in the field during irrigation and they can't irrigate at night, which means a lot more time is required to manage water. An unreliable water supply increases labor input because the farmer has to wait for water delivery. All these are associated with increased opportunity costs, as there is less time for off-farm employment."

Cash inputs -- fertilizers, pesticides, and hired labor for weeding and harvesting -- are also much higher for non-rice crops. "Institutional credit," he continues, "is scarce, and non-institutional credit carries interest rates as high as 20 percent per month. And in contrast to rice, which has an established market, the market price for non-rice crops is highly unstable." Despite the risks, farmers that take the plunge can still make a profit. But for now, it's a plunge that only the wealthier farmers can afford to take.

Following two seasons of observations, IIMI in collaboration with the operating agencies, moved to intervene in the two systems with the aim of improving the reliability and equity of water delivery below the secondary canal. "The basic management principle underlying the intervention was information feedback between farmers and agency officials," says Miranda.

"We employed two strategies," says

*In Dewahuwa, farmers can take water from turnouts at every level of the system unlike Kalankuttiya where they can take water only from the field channel turnouts.

Panabokke, "a rotational plan and post-issue meetings." A rotational plan, developed in mid-season for the distributary channels and field channels, provided farmers and agency staff with a clear set of performance targets. The post-issue

Canal flow measurements can provide managers with critical information on water distribution.

meetings, which included agency officials, IIMI field staff, and farmers or their representatives, provided the opportunity to discuss the previous issue and to plan the next issue. To assist in the process, IIMI field staff monitored canal flows and ground water tables, and surveyed farmers to provide the agency with regular information feedback on how the system was performing.

The intervention accomplished two objectives, though it was relatively more successful in Kalankuttiya than in Dewahuwa. "The equity among the field channels improved significantly," asserts Panabokke. "Ratios of 3 to 1 became 1.5 to 1. Second, there was increased interaction between the farmers and agencies concerning the rotation plans, and better communication as to when the rotational issues would take place. The rotational planning also allowed managers to accommodate crop needs by changing the frequency of issues (from 1 in 7 days during crop establishment, to 1 in 10 during the mid-growth stages, and to 1 in 7 near harvest time)."

"Understanding how the farmers and the agencies worked allowed us to bring them together. By presenting feedback to them in the form of water measurements, we created a focal point for the discussion," Panabokke says. "More importantly, increasing the reliability of rotation issues enhanced the capacity of the farmers to take over management functions below the turnout."

In the Philippines, management practices for irrigating non-rice crops are relatively undeveloped. Until very recently a major importer of rice, increased rice production has dominated agricultural policy for the past 15 years. "All irrigation planning, regardless of the season, is effectively directed toward rice," says Miranda.

There are many existing irrigation systems in the Philippines that irrigate diversified crops. The sources for moisture for dry season non-rice crops are derived from rainfall, diverted river flows for irrigation, and groundwater. Although information is available on crop water needs and agricultural practices, little information is available on effective irrigation management for non-rice crops during the dry season.

Against that background, IIMI, in collaboration with the National Irrigation Administration (NIA), the Ministry of Agriculture and Food, and the Philippines Council for Agriculture and Resources Research and Development (PCARRD), began research in 1985 to identify constraints and develop practical guidelines for irrigating non-rice crops. The research is carried out in parts of three systems (in Mindanao at the Allah Valley, South Cotabato; and in Luzon at Nueva Ecija, Tarlac, and Ilocos Norte).

"In the Philippines," says Alfredo Valera, IIMI's Resident Scientist, "the government does not yet have a working policy that promotes the irrigation of non-rice crops. Past policies have pushed rice production at all costs, in all seasons."

"At this time," he continues, "agencies don't plan for non-rice crop production. If farmers don't ask for water they won't get it. The specific water requirements of a certain crop do not come into play. The impact of government policies is that farmers will grow rice if there is sufficient water. Effectively, any irrigated non-rice crop production that takes place is the result of water shortage rather than deliberate planning.

Consequently, the Philippines research has been carried out at a very basic level which begins with demand assessment. "Currently we're working on a methodology for rapidly identifying those parts of irrigation systems suitable for diversified crops," says Valera. "To do this, we are developing a microcomputer-assisted grid cell encoding technique that produces a detailed map showing the spatial distribution of land types." The methodology is intended for operational planning where there is a minimum set of field data, as often exists in the Philippines.

As in Sri Lanka, farmers' decisions to grow non-rice crops is heavily influenced by economics -- the level of returns expected and the risk of production. The same factors come into play in Sri Lanka, the Philippines, and Indonesia: availability of labor, credit and financing, and marketing. Farmers' lack of experience with irrigated non-rice cropping, lack of irrigation management practices and unreliability of water supply, irrigation service fees, insufficient credit and marketing facilities (informal credit rates range from 13-18 percent per month), and dry season rainfall, all serve as a disincentive to farmers to grow irrigated non-rice crops during the dry season. Not surprisingly, early research results on profitability have been mixed, and only in a few locations has a significant difference in profitability been shown.

In Mindanao, the economic situation is complicated by a bimodal rainfall pattern. "Farmers in the lower portions of the system argue that rainfall is sufficient for non-rice crops," says Valera. "There is a general feeling that if they're going to pay for water, they might as well grow rice. The result is a very inefficient use of water for both rice and non-rice crops. In those systems, we have been trying to convince the farmers (using demonstration farms) that the returns on irrigated non-rice crops would more than pay for the water charges." According to research findings at that site, irrigated corn, in particular, will bring higher profits than irrigated rice. As to management practices, research is carried out at the farm and system level. Both canal flow and water tables are monitored at all sites. At the farm level, different irrigation methods -- furrow and basin flooding (the most common) -- are used for different crops with varying success of application efficiencies, ranging from 38-80 percent.

The study on irrigation management at the system level was confined to documenting the operations of each system using water measurements and data on irrigated area, status of farming activities, and water adequacy. Full results will not be out until 1989.

The Philippines research therefore is aimed at identifying the efficiency of existing ad hoc procedures of both farmers and agencies. Scientists thus monitor water flows in farmers' fields, which the agencies have not done. Based on those findings, scientists now hope to introduce systematic procedures and guidelines for delivering water to non-rice crops based on scientific principles and experience. Practices documented in Sri Lanka and Indonesia will guide this effort.

Indonesia, where IIMI began research in 1985, contains some of the most sophisticated irrigation systems in Southeast Asia. The construction costs of technical irrigation systems are much higher than in the Indian sub-continent. Cropping intensities in the research sites in Java, where the majority of IIMI's research is conducted, range between 220-350 percent. Unlike the Philippines where research is aimed at determining the guidelines for growing irrigated non-rice crops, research in Indonesia is aimed at maximizing yields from irrigated non-rice crops during the dry season through better management.

According to Sam Johnson, IIMI Team Leader in Indonesia, research focuses on supply and demand; that is, determining and improving how demand is assessed, and how supply is managed and delivered. Research is carried out collaboratively with the Directorate General of Water Resources Development and the Provincial Irrigation Services of East, West, and Central Java, where the bulk of the research is underway.

Early in the research, IIMI scientists found that the way rice was irrigated during the wet season affected irrigation of the non-rice crops during the dry season. "In rice-based systems, farmers build up the shallow water table by creating an artificial confining layer which keeps the water in the field," says Johnson. "Essentially farmers create a small lake with plants growing out of it, and irrigation practices during the wet season are planned to maintain the lake at a certain level –during rains you drain it, during dryer periods you irrigate. When you move into the first dry season, a farmer must decide whether he can maintain that lake for another season, and if he thinks he can, he will grow rice. In this case, in the absence of rains, irrigation water is used to recharge the lake.

"As you move into the second dry season," he continues," it becomes obvious to farmers that, except in a few low lying areas, there is insufficient water left in the soil profile to maintain that lake. Now the farmer has to drain the lake for non-rice crops requiring less water." This difficulty is reflected in the resultant low yields. Farmers might obtain soybean yields of 1 ton/ha, whereas a typical farmer in the US might average 3 tons/ha.

"We also noticed that farmers irrigated only once or at most four times during the dry season," Johnson adds. "It became clear that farmers were subirrigating, using water left in the lake from the previous wet season, and we later verified that by monitoring the groundwater table. With a high groundwater table, the roots run shallow along the sun-dried portion of the soil; when the lake falls, the crop is immediately stressed and the farmers irrigate. The practice was stress, response, stress, and response."

Thus irrigation managers in Indonesia are faced with two problems, managing the water in the soil profile and managing the water delivered by the irrigation system.

IIMI researchers are currently examining the relationship between the time the water table begins to fall and the timing of water delivery. "We hypothesized," says Johnson, "that if irrigation was held back to let the water table fall sooner, farmers could plant their non-rice crop sooner and have a better medium to grow their crops. This would also open the door to regular irrigations."

In general, determining water demand is far more important and far more difficult for non-rice crops. Non-rice crops vary in water requirements and length of growing season. Thus optimum irrigation management requires an adequate assessment of the mix of crops and the amount of area grown to each. "That," says Johnson, "really becomes complicated under the intense farming conditions found in most of Java."

In Indonesia, management begins at the village level. In each village a farmer is designated as a village water master, who collects information on the amount and mix of non-rice crops grown in the village's portion of the irrigation block. Every 10-15 days the village master reports this information to a water inspector, who collects similar information from every village master in the block. He then determines the amount of water that should be allocated to the block. Blocks average about 100 ha and about three plots per ha.

That information is transferred up the

Cropping intensities in Java can be as high as 350 percent.

system, where a system water master pools information from the different water inspectors, and totals the water requirement for the individual system. The demand is then compared with the available water supply. If the available water exceeds the demand, the total demand required is delivered for the next ten days. If the water supply is less than demand, the water master calculates a ratio between supply and demand. If the ratio falls below 0.7, a rotation is considered.

In Indonesia, this theory is far more difficult in practice. As management begins at the village level, so do the problems. Research results have shown that the village master's reports are very rough estimates, which, when transferred up the system, often lead to excess water being diverted into the blocks.

Johnson's team therefore began to look for a way to improve the accuracy of reporting. The team prepared a series of block maps which delineated the village blocks by color and the farmers' fields by number. The team gave these to the village water masters along with a form which they could then carry with them to the field to check off and total up the crop amounts. They gave a similar map and a calculator to the water inspector so he could randomly cross-check the accuracy of the village water masters' reports. As expected, the accuracy of reporting increased significantly.

Johnson admits, however, that there are reservations, primarily economic, about block maps. Considering the approximate 4.5 million ha in the public irrigation system, the mapping costs come to around US$ 23 million. And the maps grow obsolete over time due to changes in land holdings. Nevertheless, Johnson believes the maps would still pay for themselves. "The payback," he says, "comes in water savings because farmers tend to overirrigate at present and, to a lesser extent, in better yields."

Turning to the supply side, the team concentrated on monitoring and feedback. "Our whole approach to supply," says Johnson, "was to get the monitoring and feedback loop working." On the supply side, the manager gathers and analyzes information, and passes it upwards in the management system. At the highest level, management determines the amount of water to be released to a system and directs orders to a gate keeper to release it. The gate keeper sets the gate to release a fixed amount of water over a fixed period, according to the flow through the gate at the time of setting. It is assumed, at least in practice, that flow rate will be constant during the ensuing issue period. And that is where the system breaks down.

The source rivers in Indonesia are short and relatively fast. Rain falls in the mountains and moves quickly down the streams. The gate keeper is expected to read the gates during the delivery period, which in theory provides the manager with a monitoring and feedback system to determine when or if the flow fluctuates. "However," Johnson says, "when I looked at the data in the manager's office and saw that flow rates over a series of issue periods almost exactly equalled the planned rates, I told the manager that it was not possible."

"When we followed the feedback from the gate keeper upward, we found the data changed hands three or four times verbally or on slips of paper, and that, by the time it reached the chain of command, it exactly equalled the scheduled flow rates. The system was almost, at least on paper, 100 percent efficient," says Johnson.

IIMI staff and local provincial irrigation service collaborators developed an official record book for the gate keeper to replace the lined notebooks they generally bought in the local market. It gave the record keeper a feeling of greater responsibility, and provided a systematic way to keep records. IIMI staff have recommended that the figures recorded in the book be used as the official record. The idea has been successful to a certain extent.

"But," Johnson continues, "there is a vicious circle. Higher level officials usually do not use the field data as it is not considered accurate, and the field staff collecting the information don't concern themselves with accuracy because the information isn't used. One requirement for breaking that circle is for increased recognition among managers that operation is the main task."

Johnson contends that across Asia, there is a widespread construction mentality. Construction is perceived as the professional job for engineers, with operation and maintenance left to more junior level employees. As the construction costs of new systems increase, emphasis is gradually shifting towards operation. "But," he adds" the push has to come from the top."

IIMI's research results allow for a number of generalizations to be made on the constraints to non-rice cropping in irrigation systems. Clearly, unreliable water supply serves as a disincentive to farmers by increasing the cost of labor because the time spent waiting for water reduces the farmers' opportunities for off farm employment. The answer to that appears to be better communication between agencies and farmers.

There are greater economic risks associated with non-rice cropping than with rice. Cash and labor inputs can be three times that of rice, and can be even higher in the absence of institutional credit. Heavy investments are at risk because of the uncertainty of market prices and dry season water supplies. Despite costs and higher risks, irrigated non-rice crops are more profitable on well-drained soils during the dry season.

Assessment of water demand for crops other than rice also needs to be improved. As a system becomes more sophisticated, demand assessment becomes the constraining factor. More information needs to be collected in the field regarding the type and extent of non-rice cropping. Then water tables and canal flows can be monitored to provide feedback to managers and farmers on the efficiency and equity of irrigation.

Most important, in diversifying from rice to non-rice crops in rice-based irrigation systems during the dry season, there appears to be almost a geometrical increase in the managerial input required. That suggests that there has to be either an increase in technology or an increase in management staff. There is a third alternative, that being the transfer of management responsibility to farmers. All involve costs, though the last option is least costly to agencies while increasing the cost of labor input by farmers.

"Many experts" says Johnson, "argue that as you move from rice to non-rice crops you have to increase the hardware. I would argue that, given an existing system in Indonesia, you can increase efficiency significantly by taking the slack out of management before you reach a point where you have to put more cement in the ground. After you've improved the management level, you can then identify where the cement has to go. But management has to take the lead." □

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