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Irrigation Management for Crop Diversification in Sri Lanka

Irrigation Management for Crop Diversification in Sri Lanka: A Synthesis of Current Research

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Summary: The need to understand the technical and socioeconomic constraints in irrigation management for diversified cropping underlies this study. The main constraints identified include the unreliability and inequity of supply at the secondary and tertiary levels of the irrigation system, the lack of organization and management for sharing water below the secondary level, and the poor communication between agency staff and farmers in water delivery scheduling. Intervention studies have shown that flow measurements combined with regularly scheduled rotations and regular meetings between agency staff and farmers can enhance the management capacity of both. Because of the greater economic risks faced by farmers in growing non-rice crops as compared with rice, an assured market and a competitive price are indispensable for promoting diversified cropping.

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Preface

Prior to the development of the Mahaweli multipurpose project, the major irrigation systems in Sri Lanka were essentially designed for growing a rice crop over the whole command area during the wet *(maha)* season, and, depending on the availability of irrigation supply, for growing a second rice crop during the subsequent dry *(yala)* season in a restricted extent of the command area.

From the mid-1960s, the Ministries of Agriculture and Irrigation had encouraged and fostered the growing of non-rice or other food crops during the dry season in several major irrigation systems located in the Northern and North Central provinces of the country by offering price incentives to farmers and pressing into service the research and extension strengths of the Department of Agriculture. The level of results achieved varied, yet, no serious attempts were made to study and understand the reasons for the success or failure of the various endeavors in this field.

The more recent success recorded in crop diversification - especially dry-season chili, cultivation of which was promoted because of the water shortage during the season – in System H of the Mahaweli could be attributed to the appropriate design for dry-season irrigation operation combined with proper price incentives and an effective field extension support. Yet a clear understanding of the institutional and socioeconomic factors that constrained a fuller utilization of the available resource potential within the System was lacking. Even in other irrigation systems that recorded significant progress in crop diversification, a clear understanding of the influence of irrigation management practices and their interactions with different facets of crop diversification was lacking.

The interdisciplinary studies conducted by the research staff of the International Irrigation Management Institute (IIMI), commencing in yala 1985, have helped to clarify some of the more important technical and socioeconomic constraints, and the potential to more intensive cropping with other food crops during the yala season. The results of these studies do not claim to provide all the answers to the problems of irrigation management encountered. These results, however, provide the essential first step towards identifying future management intervention approaches and the proper directions in which they could be tested and adopted. This would make possible future strategies and policies to be based on an objective body of tested information.

The text was prepared by the author with materials obtained from the IIMI headquarters Irrigation Management on Crop Diversification Group composed of S.M. Miranda, E. Martin, D.J. Groenfeldt, N. Raby, and from IIMI's field research staff, especially, D.K.W. Dias, M. Hemakumara, R. Moragoda, R. Ekanayake, K.A. Hemakeerthi, L.R. Perera, A.P. Keerthipala, P.B. Aluwihare, and J. Upasena, and the staff of collaborative national agencies in the two irrigation schemes.

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Executive Summary

Although Sri Lanka has more than fifteen years' experience of dry-season irrigation for diversified cropping, there is a lack of clear understanding of both constraints and opportunities which are considered necessary for formulating future strategies and policies, and also an inadequate knowledge of proper management of irrigation systems for dry-season cropping with other food crops. The research objectives in this study have accordingly focused on the examination of technical and socioeconomic constraints to more intensive cropping with other food crops during the dry *yala* season. The two main components of the research are 1) irrigation systems management, and 2) crop diversification.

The first phase of the study began in April 1985 in parts of two agency-managed irrigation systems, Dewahuwa and Kalankuttiya, located in the North Central Province. The main objective in this phase was to identify the technical and socioeconomic constraints to effective diversified cropping on irrigated land. The second phase, an action-research phase carried out in yala 1987, involved pilot testing of management innovations.

In the systems management component of the research, the adequacy of delivery at different levels of the system and the scheduling and timing of deliveries together with the nature of the operation and maintenance activities were examined. It is observed that in order to ensure reliability and equity at the tertiary level of the system it is necessary to have a good standard of control and regulation at the main system level. In respect of scheduling and timing

of deliveries it is observed that there is a big gap between the planned quantity and timing of deliveries and their actual implementation. While this gap is high during the land-preparation phase, it is comparatively lower during the subsequent crop-growth phase. Several assumptions that are presently made in respect of water requirements for land preparation need to be re-examined. Opportunities exist for a more meaningful use of past rainfall data, especially the nature of variability of the early rains in planning for an opportune date for commencement of the yala season.

Interdisciplinary research conducted on the nature of the operation and maintenance activities led to the identification of three important constraints to diversified cropping: 1) unreliability and inequity of supply at the turnout level arising from inadequate control and regulation, especially at the secondary and tertiary levels of the system; 2) lack of organization and management for sharing water from the secondary level downward; and 3) poor communication between agency and farmers in water-delivery scheduling.

Arising from the foregoing, an operational research activity which aimed at pilot testing some appropriate management innovations was conducted in close collaboration with the two management agencies during yala 1987 from which the following main conclusions could be drawn.

Flow measurements constitute an important tool in management decision making and implementation. It provides an effective focal point for discussion between agency and farmers.

Regular meetings between farmer leaders and project staff after each water issue are an effective way to improve communication between farmers and agency.

Regularly scheduled rotation of turnouts enhance the capacity of farmers to take over management functions below the distributary-channel gate.

The crop diversification component of the research reveals that both Dewahuwa and Kalankuttiya systems have adequate canal capacity for the desired intermittent flow for irrigating non-rice crops, and that there is potential for expanding cultivation of other food crops to the imperfectly drained soils by good water control at the field-channel level. Empowering the Dewahuwa management staff with more authority and a better use of its institutional setup is recommended. A planting-to-harvest duration for other food crops during the yala season is optimally around 110 days.

In respect of incentives and constraints for crop diversification it is observed that the present market price and assured market for chili are attractive to farmers, while those for different other food crops such as green gram and soybean are less so. Among the more significant constraints to crop diversification are the need for a greater joint management effort between farmers and agency, the unsatisfactory level of monitoring at Dewahuwa, the difficulties associated with allocating land according to *bethma* (the institutional sharing of reduced irrigated land), and the greater economic risks that farmers have to take in cultivation of other food crops when compared with rice. Associated with this higher risk is the high cash and labor inputs required for cultivation of other food crops compared with rice, and the lack of readily available credit for farmers during the early part of the season. An assured market and competitive price are therefore essential for promoting crop diversification.

CHAPTER 1

Introduction

RESEARCH OBJECTIVES

OF SRI LANKA'S TOTAL area of 740,000 hectares (ha) of rice land, the major irrigation schemes presently account for a little over 250,000 ha. These major irrigation schemes, located in the dry zone of the country, have provided the basis for a rapid increase in rice production over the past decade. It is now recognized that these same schemes could provide the best opportunity for averting overproduction of rice in the future. National policy makers have, therefore, accorded the highest priority for more productive use of the existing irrigation infrastructure of these schemes through intensification of diversified cropping and more effective irrigation systems management.

Since the late 1960s efforts were made by different government agencies under the Ministries of Agriculture and Irrigation to promote non-rice crops in several major reservoir irrigation systems during *yala*, the dry season, when water supplies are usually restricted. The approaches adopted over this period had only limited success because of the lack of a clear understanding of the constraints to diversified cropping, as well as an inadequate knowledge of managing the irrigation system for non-rice cropping during the dry season. The Sri Lanka-IIMI Consultative Committee[1] at its initial meeting in early 1985 accorded the highest priority to a study of irrigation management for crop diversification under the proposed Sri Lanka field operations activities.

[1]This committee includes irrigation management specialists and officals from irrigation agencies as well as IIMI staff. Its aims are to ensure that IIMI's program is responsive to Sri Lanka's needs and to communicate IIMI's research findings to key officials of irrigation management agencies.

Underlying the present study is the assumption that more productive use of the existing irrigation infrastructure and the land and water resources can be achieved by intensifying diversified cropping systems and through more effective irrigation systems management.

The research objectives are focused on the examination of the technical and socioeconomic constraints to more intensivė non-rice cropping during yala. The findings of this research study would serve as a basis for developing and recommending policies and practices, including appropriate water control, to promote more intensive diversified cropping. The two main components of the research are *irrigation systems_managementt* and *crop diversification.* Under Sri Lankan dry-zone conditions these two components are closely interdependent and are of equal importance.

The specific objectives of the irrigation systems management component are to:

1. assess the adequacy of water deliveries at various levels, including the farm field level, from the perspectives of both the water suppliers and water users;

2. identify underlying principles of irrigation management (e.g., procedures for decisions on the timing and amounts of water allocated at various levels within an irrigation system - both before the irrigation season begins and during the season when unexpected water shortages may occur;

3. identify the nature of operations and maintenance activities by the main system management, tertiary system management, and individual irrigators, and the nature of institutional relationships among them;

4. based on the above objectives, identify and pilot-test possible improvements in irrigation management to facilitate the growing of irrigated crops; and

5. make recommendations on the adoption of improved irrigation practices in crop production based on an assessment of the impact on irrigation and crop-production performance of the pilot-tested practices.

The specific objectives of the crop-diversification component are to:

1. identify existing and potential irrigation practices for non-rice crops at the main system, tertiary system, and farm field levels;

2. identify incentives for and constraints to the further expansion of non-rice crops;

3. identify and pilot-test possible improvements in irrigation management to facilitate the growing of non-rice crops in areas where soil conditions, topography, crop profitability, and other factors generally favor non-rice crops; and

4. make recommendations concerning the adoption of improved irrigation practices in irrigated non-rice crop production, based on an assessment of the impacts on irrigation and crop-production performance of the pilot-tested irrigation practices.

The research methodologies paid special attention to social, economic, and agricultural factors related to a better understanding of irrigation management technologies. The following factors were examined: physical factors such as water supply, drainage, and soil characteristics; biological factors such as type of non-rice crop, length of growing season, and water requirements; institutional factors such as requirements for labor, technology, water, and farmer-agency interventions; and economic factors such as profitability of cultivation practices and yield risk.

RESEARCH SITES

The research sites were selected in relation to the following criteria: 1) presence of other food crops or non-rice crop production during yala, 2) type of administration of the system, 3) nature of the water source, and 4) size and age of irrigation systems. These criteria were considered because they cut across a wider range of irrigation systems found in the country than other factors such as design, layout, and manner of regulation.

Two reservoir schemes located in the Dry Zone of the North Central Province were selected: the relatively new Kalankuttiya Block of the large Mahaweli H System under the Mahaweli Economic Agency, and the older and medium-sized Dewahuwa Irrigation Scheme under the Irrigation Department and the Irrigation Management Division. A summary of some important characteristics of the two research sites is given in Table 1.

Table 1. Characterization of field research sites.

Location	Service area (ha)	Age	Type administration stration	Nature of water source	Crops and cropping pattern	Soils and drainage	Rainfall pattern
Dewahuwa	1215	Settlement commenced in 1949	Irrigation Department and Irrigation Management Diversion	Own catchment and occasional diversion from Nalanda Oya Reservoir	Wet-season rice and dry-season other food crops	Alfisols Well-drained RBEs[a] on upper slopes and poorly drained LHGs[b] in valley	Bi-modal rainfall • 1500mm/ year *Wet* from Oct. to Jan. and April to May
Kalankuttiya	2040	Settlement commenced in 1977	Mahaweli Economic Agency	Diversion from major river storage system and local storage	Wet-season rice and dry-season mainly chili	Same as above	Same as above

[a]Reddish-brown earths.
[b]Low-humic gleys.

A brief description of the physical characteristics of the two systems is given below.

The *Dewahuwa Irrigation Scheme* consists of a reservoir with a capacity of 12 million cubic meters (9,898 acre-feet) and a channel network commanding a total area of 1,215 ha. The command area is divided into nine irrigation tracts (Figure 1). The main canal is 16 kilometers (km) long and has a design capacity of 2.72 cubic meters per second (m^3/sec) (96 cusecs) at the head. The transit time for water to reach the tail end of the canal in the filling phase at the beginning of a rotation is around 12 hours. The individual farm allotments of two hectares each are served by a network of distributary and field channels. The source of supply to farm allotments is from field-channel outlets as well as from direct outlets either from the main canal or a distributary channel.

Under a project funded by Japan in the early 1970s, the main canal was desilted, slopes were stabilized, regulating and measurement structures were installed in the main canal, and steel gates and rectangular sharp-crested weirs were installed at the heads of the distributary canals. Most of the canal regulators are in poor condition at present and their gates are either missing or damaged. Turnout gates, especially in direct turnouts from the main canal and distributaries, are also in poor condition.

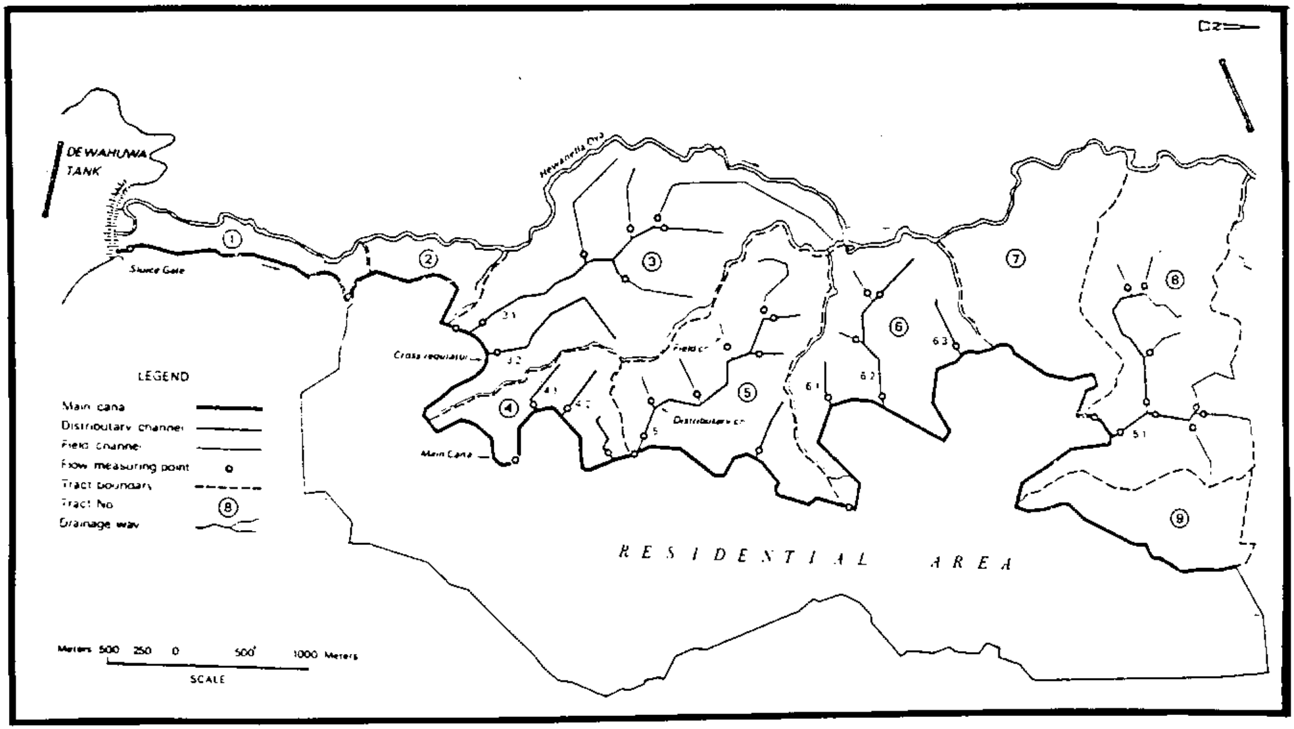
The *Kalankuttiya System* consists of the Kalankuttiya Tank, which has a capacity of 1.86 million cubic meters (1,534 acre-feet) and which receives supplies from the main Mahaweli System. The water distribution system (Figure 2) consists of a branch canal and 20 distributary channels serving a command area of 2,040 ha. The branch canal is 11 km long and has a maximum design capacity of 5.65 m^3/sec (200 cusecs) at the head-end area. The distribution system provides irrigation to five irrigation blocks, numbers 305 to 309, within the whole of the Kalankuttiya Administrative Block. Duckbill-weir cross regulators help to maintain the desired hydraulic head at different sections of the canal, thereby ensuring a controlled discharge to the distributaries.

All distributary-channel outlets have a measuring weir immediately below the gate. The field channels that take off from the distributary channel have turnout gates, of which some have been either removed or damaged by farmers.

Organizational Structure

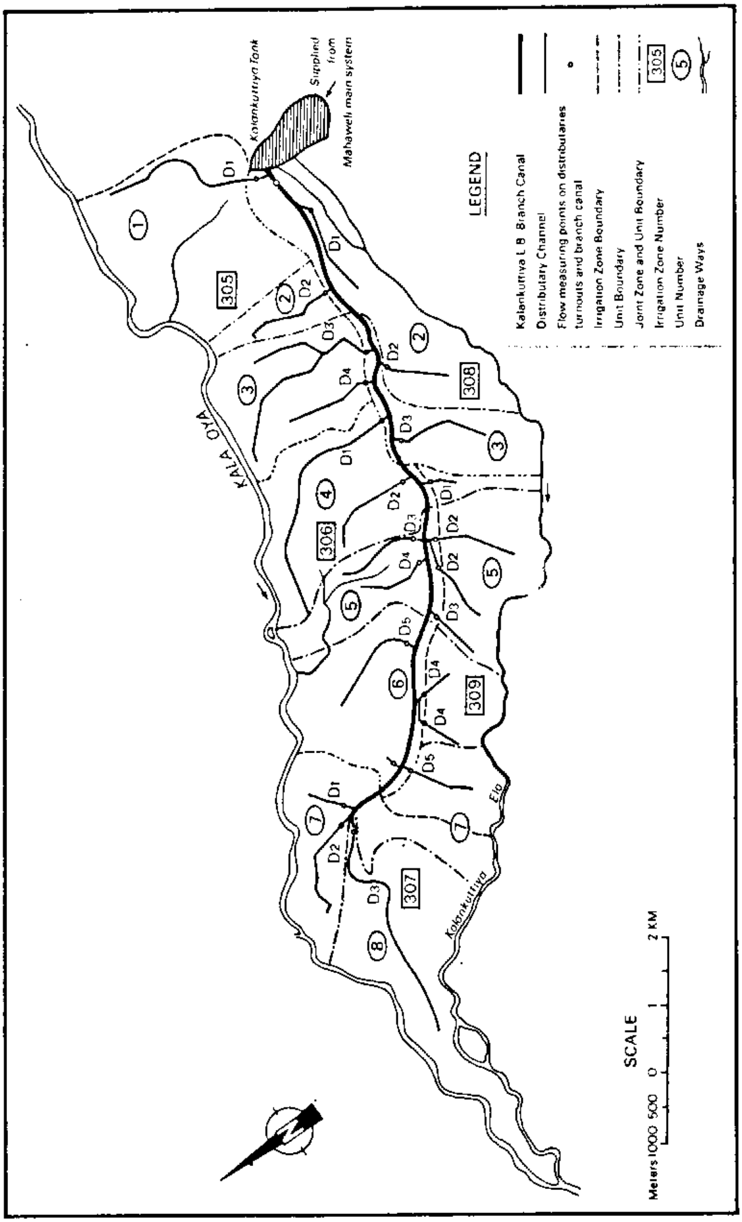
The Dewahuwa Irrigation Scheme is one of the 35 special projects under the Program for Integrated Management of Major Irrigation Systems (INMAS) of the Ministry of Lands and Land Development, which is jointly managed by the Irrigation Department and the Irrigation Management Division of the Ministry. The field staff consists of the Project Manager representing the Irrigation Management Division, and the Technical Assistant representing the Irrigation

Figure 1. Dewahuwa Irrigation System



Source: Panabokke, C.R.; IIMI Irrigation Management for Crop Diversification Group (1988).

Figure 2. Kalankuttiya Block of Mahaweli System H.



Source: Panabokke, C.R.; IIMI Irrigation Management for Crop Diversification Group (1988).

Department. Opening and closing of gates and operation of canal regulators are performed by a work supervisor and three to four field irrigators who take orders from the Technical Assistant.

The lowest functional unit is the turnout group which is loosely structured, and a farmer representative is expected to be the spokesman for his group. There are 28 such groups, whose membership varies from 25-75. Three Tract Committees are formed from the 28 turnout groups; one for Tracts 1 to 4 and the other two for Tracts 4 to 7 and 8 to 9. Each Tract Committee meets every first and third Friday of the month, and field-level problems are expected to be brought up and decisions taken towards their possible solution.

Above these three Tract Committees is the Project Committee which consists of the Project Manager as Chairman, the Technical Assistant, the Divisional Officer of the Department of Agrarian Services, the Colonization Officer of the Land Commissioner's Department, the Agricultural Officer and the Agricultural Instructor of the Department of Agriculture, and 12 farmer representatives from the 3 Tract Committees. This Project Committee holds a meeting every second Friday of the month, and brings together officers of all line departments.

The Project Manager coordinates the activities of the line departments and attempts to resolve problems relating to agriculture, irrigation, credit, marketing, and training which are brought up by the farmer representatives at these meetings.

The Mahaweli Economic Agency (MEA) is the managing agency for System H which is made up of three project areas - Galnewa, Thambuttegama, and Nochchiyagama - each under a resident project manager. Each project is further divided into blocks. Kalankuttiya Block is one of the five blocks which fall within the Galnewa project area, and it is under a block manager. Kalankuttiya Block is further divided into eight units numbered one through eight, each under a unit manager.

Each block consists of about 2,000-2,500 farm families and the block-level management staff consist of an irrigation engineer, an agricultural officer, and other supporting staff under the block manager. The block manager is responsible for overall coordination at the block and reports to the resident project manager. The irrigation engineer is responsible for water deliveries and scheduling and all maintenance work within the block, while agriculture plans are prepared and implemented by the agricultural officer.

The block-level engineering staff consists of an irrigation engineer, three engineering assistants, three technical officers, and a draftsman. The main function of the engineering assistant is to help the irrigation engineer in managing the system. One engineering assistant does only water management in the main system from the tank to the distributaries under the irrigation engineer's instructions. The other two engineering assistants are responsible for the maintenance of the irrigation network.

The administrative unit under a unit manager consists of 200-250 farm families each. He has direct contact with the farmers, and his role encompasses a multiplicity of tasks which include coordinating the timely supply of agricultural inputs to farmers, communicating with the line agencies at the block-level on behalf of farmers, and attending to water management as well as the health and welfare of farmers.

CHAPTER 2

Irrigation Systems Management

PLANNING PROCEDURES

PLANNING PROCEDURES FOR Dewahuwa and Kalankuttiya schemes adopt different approaches both on account of the different nature of the administrative and organizational structure between the two, and also because of the difference in the age, physical layout, and design between the two schemes. These differences in characteristics between the two schemes have an important bearing on the planning procedures connected with the evaluation of monitored information and water allocation and scheduling.

Dewahuwa

The management agency in Dewahuwa makes use of only gross data of previous years in planning for the oncoming season. These include total ex-sluice issues for each season, total inflow, past rainfall, area cultivated without accounting for illegal extent, probability of diversion from Nalanda Oya Reservoir, and past crop performance in relation to water duty. All the foregoing data is handled and stored by the Technical Assistant of the scheme, who has been in residence in this scheme for over 10 years. The only definitive data he has in hand before the commencement of a season is the storage in the reservoir, the probability of inflow from Nalanda Oya, and the expectancy of rain based on past rainfall records.

The Technical Assistant essentially makes the decisions regarding the dates of water issue, extent to be cultivated, duration of season, and rotational schedule. His decisions are generally conservative, and these are ratified at the *kanna* (cultivation) meeting by the project management and farmers. It should also be borne in mind that the physical characteristics of the Dewahuwa Scheme with its inadequate regulation and control devices do not permit a refined system of water delivery.

The area to be cropped for a particular season is determined jointly at the pre-kanna meeting by the Project Manager, the Technical Assistant, officials of the Department of Agriculture, the representative for the Government Agent, and the farmers. The different options of extent, age of rice crops for *maha* (wet season), and mix and extent of other food crops for yala are presented to farmers by the management based on their judgment. Both agency staff and farmers have a good understanding of the extent that could be catered for with the available water, and broad agreements are arrived at in respect of the extent and portions of the system that will be served during the season.

The more difficult decisions relate to the allocation and scheduling of water. These are usually discussed at the fortnightly meetings of the Tract Committee and the monthly meetings of the Project Committee. In the absence of any measuring devices, no reliable measure of how the water has been distributed at the different levels of the system, except a gross estimate made by the Technical Assistant based on ex-sluice issue values, is available. Farmers representing the different sections of the system report on whether an adequate supply has been delivered to their sections. The Technical Assistant then gives instructions to the irrigation laborers to adjust the distributary-channel turnouts in a way that would supply farmers' requirements. The scheduling and amount of delivery for each issue is again determined by the Technical Assistant according to his own perception, and he issues an amount slightly in excess of the actual requirement to compensate for the lax management. Agreements are also reached at the pre-kanna and monthly meetings of the Project Committee on the nature of channel maintenance to be done by farmers both before the season and in-between rotations. Any major maintenance that will be undertaken on the main system is also explained to farmers and their concurrence is sought, as this expenditure comes out of the Irrigation Department's budget.

Kalankuttiya

Monitored information is available for the previous years from the distributary-channel level up to main-sluice deliveries. Past records are also available of the areas planted to different crops during the respective seasons and the pattern of water allocation and scheduling. This past data is used as a general guide for planning the forthcoming season. For yala, plans for the Kalankuttiya Block depend on the Seasonal Operation Plan (SOP), prepared by the Mahaweli Economic Agency, which gives the total volume of water available for the season. Decisions on the extent of *bethma*,[2] duration of crop, irrigation schedules, and last date of water issue are worked out by the project-level officials in relation to the broad guidelines of the Seasonal Operation Plan.

Dates for the first issue of water for land-preparation activities are fixed in consultation with the date of diversion from Polgolla and the level of water in the Kalawewa Reservoir. For maha, a continuous 30-day issue is given for land preparation followed by weekly rotational issues for the crop-growth period. For yala, a similar pattern is adopted with some variation during the crop-growth period.

Plans for water allocation and scheduling are well established for Kalankuttiya. The design of the system with good regulation and control down to the field-channel outlet, and the uniform one-cusec[3] capacity of field channels enables the drawing up of a practicable operational plan.

Staff at many levels are involved in the planning procedures - these include the Resident Project Manager, Deputy Resident Project Managers, the Irrigation Engineer, the Engineering Assistant, the Block Manager, and the Unit Manager. Thus, compared with Dewahuwa, there is a better input of knowledge, experience, and past data into the planning process.

Maintenance work within the field channels is done by farmers adjacent to the channel, and maintenance of distributary channels is given on contract by the agency to farmers. The agency undertakes regular repairs and maintenance of physical structures.

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[2]Bethma is a practice whereby a portion (ususally 50 percent) of the total command is irrigated during a water-scarce season, and farmers have rights to cultivate an area in proportion to their land holdings.

[3]1.0 cusec (cubic foot per second) = 28.3 liters per second.

IMPLEMENTATION

Dewahuwa

Water delivery along the main canal, especially to the tail-end tracts, is beset with several problems. The main canal is presently in poor physical shape because of a lack of maintenance over several years. It is silted up in several portions along its length and it has a very low gradient beyond Tract 6. The few regulators along its length are in poor condition and can be easily tampered with by farmers. Pushing a reliable supply of water down the main canal to the lower tracts is therefore difficult, and it is also further complicated by farmers at the direct turnouts in the head end of the main canal illegally opening the offtake gates. The management, however, has been able to resort to rotational deliveries between the tail-end tracts and head-end tracts to bring about a reasonable allocation among the tracts. During the yala season, when a bethma is practiced over half or one-third of the extent, management of the main canal has proved to be less difficult.

Sharing of water between turnouts to field channels does not normally follow the scheduled plan. The designated farmer representatives are not able to perform their allocated task of closing and opening the gates as scheduled. Most gates, however, lack locking devices and even control rods and flash boards. Farmers at the head end of the distributary channel usually tend to take an oversupply during the day, and farmers at the tail end have to manage with the night flow which, at times, can be very high and erosive. This is reflected in the high degree of variation observed for deliveries between turnouts in all seasons.

Because of the unreliability of delivery at the turnout level, farmers find it difficult to draw a fixed volume of water over a fixed time at the farm inlet. This is further complicated during the bethma sharing. Measured values of on-farm water application show a wide range from undersupply to oversupply both for rice as well as other food crops.

A major advance made at Dewahuwa is that of land preparation for other food crops in yala using the March-April rains. In yala 1985 and 1986 an irrigation supply of 174 and 121 millimeters (mm)[4] was used for land preparation for these crops. In yala 1987 farmers were able to prepare the land for other food crops without any irrigation issues by only making use of the early yala rains of 171 mm.

Despite repeated attempts it has not been possible to keep to the scheduled 30 days allocated for land preparation for maha. Little consideration is given to factors such as the workability of the soil under a particular moisture regime, the nature and intensity of the weed load on the field, the availability of farm power, and cash resources of farmers. Repeated appeals made over the years by management to farmers to take advantage of the early rains for land preparation in order to save irrigation water have been rarely implemented. As an example, in Dewahuwa, during early maha of 1987/1988, a total of 621 mm of rain was received over a 45-day period before land preparation commenced.

Following the land-preparation phase, the management of rotational issues during the crop-growth phase has settled down to a workable procedure especially when there is sufficient water at the source. The rotational intervals both for rice in maha and other food crops in yala have been accepted by farmers. Some modifications, however, are made during very dry periods in yala. Rotational issues between distributaries are mainly managed by agency staff and operate according to the planned schedule. Rotational sharing of water between field channels along a distributary, however, do not work out so smoothly. For instance, in a four-day water issue period when it was agreed that the tail-end turnouts in the lower half of the distributary will take water for the first two days, followed by the head-end turnouts for the third and fourth day, many disruptions were caused by farmers. Rotational sharing of water in long field channels is also beset by similar problems.

Minimum maintenance is carried out on the main canal in-between seasons, except for very pressing repairs to the regulator planks. Desilting of parts of the main canal was carried out only once during the last three years. It is reported that there is a lack of funds from the Irrigation Department for work of this nature. Maintenance of distributary channels is confined to clearing the weed and shrub growth before the season, and some essential repairs to turnout gates and structures. Maintenance of field channels is carried out by farmers as agreed at the kanna meetings, and this work is confined to clearing of weeds

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[4]1.0 mm = 0.03937 inch

and some desilting operations. The closed season in-between the two cropping seasons is not effectively used for essential maintenance work.

Kalankuttiya

Good control and regulation is provided along the branch canal because of the positive design features such as duckbill weirs, and the good condition of distributary turnouts which have measuring devices of a robust nature. Flow measurements over the last 6 seasons show a high degree of equity in delivery among the 20 distributaries. Similarly, deliveries along the distributaries up to the field-channel turnout are managed satisfactorily, except in the case of very long distributary channels. The supporting agency staff have adequate capacity and competence to implement the delivery plan down to the turnout level in a satisfactory manner. When there is sufficient head at the main sluice of the Kalankuttiya Tank, the management has no difficulty in implementing the delivery plan according to schedule. When the water level at the main sluice falls below 1.5 meters (5 feet), appropriate modifications to the delivery plan have to be made on a day-to-day basis in order to ensure equity of delivery among the 20 distributaries. Also, during the land-preparation period in the early phase of the cultivation season, difficulties are experienced in meeting the total demand requirement for land soaking, plowing, and puddling. These difficulties are relaxed during the subsequent rotational issue period for crop growth.

Even with the good delivery system that is available in Kalankuttiya it has not been possible to keep to the scheduled 30 days allocated for land preparation either for maha or yala. The same reasons as those adduced for Dewahuwa can be given for this extension of the land-preparation period, and also an added consideration that the presently available land-preparation technology does not permit farmers to use the initial maha rains for preparing their land for puddled rice on the well-drained soils.

In the rotational-issue period during the crop-growth phase, there is less stress on the delivery system down to the turnout level when there is an adequate head of water at the main sluice. But, during the dry yala season if the water supply in the branch canal is limiting and the distributary channel is not able to provide the demand for all turnouts within it, quick modifications to the initial plans have to be made. This would involve modifying the time of delivery to each turnout but maintaining the one-cusec flow. Rotational issues among the turnouts within the four days of delivery are usually practiced.

Sharing of the one-cusec flow among farmers within the field channel does not take place according to the scheduled plan. The system has been designed to operate in a manner below the turnout whereby two farmers at a time share a stream flow of half a cusec each for a 12-hour duration, so that a total of 16 farm allotments could complete their irrigation within a period of 4 days or 96 hours. What normally takes place is that each farmer takes the full stream of 1 cusec to his allotment for a period of 6 to 8 hours, and this is followed by the next farmer. There are many other variations to this pattern at the land-preparation period, the crop-growth period, and also according to the distribution of different other food crops in the same turnout during yala. If the farmer representative and the agency can ensure a steady one-cusec flow at the head of the turnout, then farmers find it convenient to work out their own informal rotational schedule within the field channel both for maha and for yala.

The date for the close of yala scheduled for end-August is not always observed, mainly because the chili crop extends well beyond the end of August and often to mid-September. One attempt made in yala 1986 to establish the chili crop before the Sinhala New Year in mid-April failed because of excessive rain soon after planting. Maintenance has to be therefore very hurriedly carried out during the short period available before the commencement of the subsequent maha season. The date for the ciose of maha scheduled for mid-March is usually observed because there is often no water available from the reservoir during this period. Maintenance work in the form of channel clearing and cleaning is done by farmers, while the agency attends to minor repairs of structures, gates, etc., during this period.

MONITORING

Dewahuwa

Monitoring of deliveries in relation to demand is carried out essentially at the point of the main-sluice issues. Deliveries from the main sluice are recorded on a daily basis by the Technical Assistant, who makes a gross comparison with the targeted water budget that he has prepared before the kanna meeting. No serious attempt is made to quantify the demand, but instead the Technical Assistant makes use of his personal experience based on past seasonal issues to gauge how much he should issue for a specific command area. The matching of deliveries with demand, and the issue of water to distributaries and field channels is usually based on farmer complaints made during the course of the issue week. In the absence of any reliable quantitative base of information the Technical Assistant responds by ad hoc operation of the sluice gates to extend the duration of flow in response to farmers' demands. Furthermore, in the absence of daily rainfall data across the scheme, even the regulation from the main sluice cannot be effectively implemented across the system.

The evaluation of water deliveries is essentially based on farmer reactions expressed at the fortnightly meetings of the Tract Committee where farmers make qualitative statements on their perceptions of adequacy of supply. This, however, does not give a proper assessment of the total system because of a lack of essential information as to which part of the system actually suffered from an undersupply and which part from an oversupply, and the reasons for this.

In the main canal, which is 16 km long, much variation in flow is observed at the 3 measuring points. During the land-preparation phase, it is difficult to push the full supply required for the tail-end tracts. Illegal opening of direct turnout gates by head-end farmers, and the variation in flow that takes place in some of the larger distributary channels because of the unpredictable opening and shutting of turnout gates by farmers are the main contributory causes for this variation.

Although no measurements were made, there are significant losses in drainage out of the system. During yala especially, it appears that there is a tacit understanding between the agency and farmers that the amount of water released from the main sluice should satisfy the needs of the authorized bethma extent, and also have some drainage overflow to meet the demands of those farmers who lift water from the drainage ways and grow other food crops very successfully on the levees and adjacent high ground.

Although there is an organizational setup that conforms to the Irrigation Management Division-Integrated Management of Irrigation System (IMD-INMAS) model in which 28 turnout groups are grouped into 3 Tract Committees, the best use is not made of this organizational structure to resolve field and irrigation problems. Owing to poor information flow between farmers and the project management on when and where water would be issued, farmers are not able to adhere to a plan. As there is no clear-cut plan for delivering water from the turnout to the farmer outlet, the turnout gates are operated both by the farmer representatives and the farmers. The irrigation staff consists of the Technical Assistant, the work supervisors, and two irrigation laborers. They are able to exert their influence mainly at the main sluice, and the distributary turnouts. A proper operational approach for sharing the responsibility for managing the field channel and direct outlets between the farmer representatives and irrigation staff has yet to be worked out. Good supporting services are, however, provided by the field staff of the Agriculture Department in provision of good seed material, training in pest and disease control, and general agronomic practices.

The lowest unit in the formal organizational setup at the field level is that of the turnout group. Each turnout group consists of 11 to 23 allotments, and farmers choose a turnout group leader or a farmer representative. Above the turnout group is a Tract Committee comprised of farmer representatives, the Work Supervisor of the Irrigation Department, the Cultivation Officer, and the Field Instructor of the Land Commissioner's Department. As discussed earlier this Committee meets every fortnight, where the main matters discussed are irrigation problems. The farmer representatives are expected to meet the farmers of their respective turnouts in the field at least once a week at a convenient time to discuss problems as well as suggestions of farmers and bring these up at the meeting for discussion and resolution. It is observed that these meetings are poorly attended and are effective only when a common problem is encountered.

Reported chili yields in yala were 0.9 tons/ha in 1985 and 1.1 tons/ha in 1986. Green gram yields increased from 0.6 tons/ha in 1985 to 0.75 tons/ha in 1986. Soybean yields also improved from 1.4 tons/ha in 1985 to 1.8 tons/ha in 1986. Yield of rice was 1.3 tons/ha in 1985 and 2.3 tons/ha in 1986. Data show that non-rice crops are more profitable than rice. Returns to farm resources for chili were approximately Rs 19,000/ha[5] compared to Rs 1,300/ha for rice in yala 1985; and in yala 1986 returns to farm resources for chili were approximately Rs 13,300/ha compared to Rs 3,700/ha for rice.

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[5]US$1.00 equaled Rs 26.45 in 1985 and Rs 28.20 in 1986

Yields and returns to production were much higher for the rice crop in maha than in yala. Reported yields in maha, as well as estimates from crop cuts, averaged about 4.6 tons/ha. Returns to farm resources for the maha rice crop averaged Rs 8,752/ha compared to Rs 1,300/ha in 1985 and Rs 3,700/ha in 1986 yala seasons.

Chili production, however, requires a much higher cash outlay than does rice. The higher cost of chili production is mainly due to greater use of fertilizer and pesticides and the need for large amounts of hired labor.

Kalankuttiya

Monitoring of deliveries in relation to demand is carried out by the Block Irrigation Engineer and his staff Engineering Assistants, both at the main sluice and distributary off-takes. The Irrigation Engineer in charge of the Kalankuttiya Block monitors the deliveries from the main sluice of the Kalankuttiya Reservoir and matches it against the deliveries from the distributaries to ensure that the delivery adequately meets the planned demand. Quantitative data is available for daily discharge values of the main sluice, branch canal, and distributaries. The Engineering Assistant makes a weekly computation of the deliveries in each of the 20 distributaries. At the weekly meeting of the Block Manager and his staff held every Saturday during the cropping season the Unit Manager and his field staff are briefed by the Engineering Assistant on the daily and weekly issues at the unit level, the extent of land that was covered by irrigation for that week, and the purpose for which the issues were made at the different stages of cultivation. These weekly meetings are useful for information feedback from field-level staff to block level-staff.

While good quantitative data is available down to the distributary level, comparable data is not available at the field-channel turnout level. The plan for rotations among field channels within a distributary channel, and the plan for duration of flow for the respective field channels is, however, available, and the unit managers with the assistance of the irrigation laborers are able to monitor the performance at the turnout level in respect of these plans. The main problem of inequity arises at this level of the system. If each turnout had a similar number of allotments under its command, and one type of soil within it, then a standard time module of delivery would have been feasible. But, with the variation in number of allotments per turnout, and the variation in ratio of well-drained to poorly drained soils under each turnout, as well as variation in farmers' resources and behavior, it is difficult to implement a smooth operation plan at the turnout level. Despite these problems, the intervention study conducted by IIMI in yala 1987 showed an approach that could be taken at the turnout level in order to ensure reliability and equity of delivery at the turnout and allotment level.

There is very little variation in flow in the branch (main) canal after a steady state is reached and when all 20 distributary gates are set at a known discharge. Similarly, variation in flow in the distributary channels occurs when there is unscheduled opening of turnout gates, or else when gate settings at the turnout are interfered with by farmers.

The block-level engineering staff consists of one irrigation engineer, three engineering assistants, three technical officers, and a draftsman. One of the engineering assistants does only water management in the main system from the Kalankuttiya Tank to the distributaries under the instructions of the irrigation engineer. He calculates the diversion requirement to each and every distributary and at the main-sluice level. Water flows in the branch channel and all 20 distributaries are monitored daily. The irrigation laborers, apart from their main duty of adjusting gates, give daily reports of flow measurements to the Block office where the engineering assistant uses this data to calculate the actual water deliveries for all distributaries.

At the weekly Saturday meeting held at the Block office where staff discuss and evaluate progress, the water-flow data along with progress of land preparation, cropping patterns, and other important issues are discussed and necessary steps are taken to correct conditions of reported undersupply or oversupply. Channel maintenance work done by private contractors is also reviewed during these meetings. The organizational setup works well down to the level of the Unit which usually covers two or more distributaries.

Farmer group action for sharing of water among field channels and within them is not properly developed. The distributary-channel representative is expected to play a role in ensuring a proper sharing of water among field-channel turnouts, and the field-channel representative in sharing of water among allotments within the channel. The irrigation laborer attached to the unit manager is responsible for operating the turnout gates. Coordination and communication between them is not adequately developed, and this sometimes results in haphazard and disorderly allocation of water during times of shortage.

Reported chili yields in yala were 1.9 tons/ha in 1985 and 0.97 tons/ha in 1986. The poor performance of chili in 1986 yala is attributed to heavy rains experienced in the early part of the season, high incidence of disease, and the larger extent cultivated in each allotment. Returns to farm resources for chili were approximately Rs 41,000/ha compared to Rs 3,700/ha for rice in yala 1985; in yala 1986 returns to farm resources for chili was approximately Rs 14,100/ha compared to Rs 5,100/ha for rice.

Rice yields in maha were considerably higher than for yala 1985 or yala 1986. The average yield reported for maha was 4.2 tons/ha. Returns to farm resources for the maha crop were Rs 7,692/ha compared to Rs 3,720/ha in yala 1985 and Rs 5,100/ha in yala 1986. As in Dewahuwa, chili production requires a much higher cash outlay than does production of rice.

CHAPTER 3

On-Farm Water Management

PLANNING BELOW THE TURNOUT

Dewahuwa

ALTHOUGH THERE IS no formal planning process below the turnout level, the agency explains the proposed water-delivery schedules to the turnout groups at the kanna meetings. For yala, water issues are guaranteed for only a four-month period (1 May to 30 August), with a rotational issue of 2.5 days on and 7.5 days off. Rice is permitted on poorly drained soils but with the above rotational schedule. For maha, there is a planned rotational pattern based on turnout groups. The rotational issue is four days on and three days off, with the long distributaries receiving water on the first two days to a part of the area, and on the next two days to the rest of the area.

Kalankuttiya

If there is a shortage of water for yala and a bethma has to be practiced, the Unit Manager, with the assistance of the field assistants, distributary-channel representatives, and turnout leaders select the turnouts which would receive water on the basis of proximity to distributary gates and soil type. They also prepare a proposed cropping pattern based mainly on soil type. For land-preparation activities a continuous issue for a 30-day period is planned, and is followed by rotational issues during the crop-growth period. The proposed rotation is once in seven days at the allotment level.

IMPLEMENTATION OF WATER DELIVERY

Dewahuwa

There is a big gap between the proposed plan and its implementation at the turnout level. The plan for head-end turnouts to take their share of water on the first day and for tail-end turnouts to take on the second day is not actually followed. Everyone below the turnout takes water at the same time and there is no sharing of water on a rotational basis. During maha, farmers are unanimous in their view that the tail-end turnouts receive the least amount of water. Because of poor information flow between farmers and the project management on when and where water will be issued, farmers are not able to adhere to a plan. As there is no clear-cut plan for delivering water from the turnout to the farmer outlet, the turnout gates are operated both by farmer representatives and by other farmers.

Kalankuttiya

There is no systematic pattern of sharing water below the turnout, except that farmers growing other food crops irrigate their crop during the day and rice is irrigated at night. Because there is no systematic method, the time taken to irrigate an allotment is highly variable. Water distribution in turnouts follows various patterns and it is generally observed that adherence to the prescribed 12-hour rotation is more an exception than the rule. In most instances, water sharing at the field-channel level is not properly planned and whatever degree of sharing that is achieved is by an informal type of arrangement.

ANALYSIS OF WATER DELIVERIES

Dewahuwa and Kalankuttiya

For Dewahuwa it is observed that there is a high degree of variation in the amount of water delivery between turnouts, which reveals a low level of control and regulation along the distributary. The project management is not capable of responding rationally to farmers' complaints of undersupply except by making ad hoc modifications either at the main sluice or distributary turnouts. This is further aggravated by the poor state of the turnout gates and the poor communication between the farmers and the agency. It is observed that in Kalankuttiya control and delivery could operate more satisfactorily in order to ensure a better degree of equity in delivery to turnouts, and that improved communication between the farmers and the agency could enhance the reliability of deliveries.

Management problems below the turnout level are more complex at Dewahuwa than at Kalankuttiya. The nature of the design of the tertiary system of Kalankuttiya enables an easier operation compared to the older Dewahuwa Scheme. Furthermore, the bethma sharing practices are more difficult to implement in Dewahuwa owing to the physical characteristics of the irrigation layout and the larger number of farmers involved.

On-farm delivery values measured for most other food crops are around 500 mm during yala for Dewahuwa; for Kalankuttiya it is slightly higher. When, however, compared with seasonal evaporation of 500 mm for the dry season, it would indicate a situation close to adequacy of supply at the allotment level in most instances. This is, however, masked by the wide dispersion of values recorded for on-farm delivery which would thereby indicate a wide spread of conditions for on-farm irrigation supply.

CHAPTER 4

Comparisons

IRRIGATION MANAGEMENT PRACTICES

Planning

THE BASIC PRINCIPLE in the planning stage of irrigation management is to match the water supply or delivery with the demand for land preparation and subsequent crop growth. While Dewahuwa, which is managed under the aegis of the Irrigation Management Division adopts a relatively simple approach in the planning process, Kalankuttiya, which is managed by the Mahaweli Economic Agency adopts a more elaborate approach as is common for larger irrigation schemes.

In both schemes, however, the agency staff meet with farmers at the kanna meeting before the commencement of the season to agree on the following:

a) date for commencement of season, b) extent and types of crops to be grown, c) duration of land-preparation period, d) commencement of rotational irrigation, e) close of season and last date of irrigation, f) method of irrigation distribution, and g) maintenance schedule. At this meeting the agency staff present the plan for the forthcoming season based on quantitative data and past experience. While Kalankuttiya has a good body of quantitative data on which a sound plan can be prepared, in Dewahuwa the plan is based more on past experience and personal judgment.

Estimating probable future supply after commencement of the season is the main responsibility of the engineering staff of the agency. In the case of Kalankuttiya the Water Management Secretariat provides a seasonal operation plan which is based on quantitative information of past river flow data and on probabilities of flow during the oncoming season. The Flow-Monitoring Unit of System H is responsible for monitoring within the subsystems of System H. A step further down at the Block levels, the Block Manager and his engineering staff are responsible for allocation within the block. The engineering staff at all three levels have had regular training and also the necessary equipment to carry out their task. In Dewahuwa there is only one technical officer, the Technical Assistant, for the whole scheme who has once had a short training, but does not have the essential equipment. He has to adopt simple rule-of-thumb methods and rely on his past experience.

In Kalankuttiya, deliveries for the land-preparation period (30 days) and the subsequent crop-growth period are based on empirically derived values. It is 188 mm for the land-preparation period, and 63 mm per issue for a 7-10 day interval during the crop-growth period. Because of the presence of measuring devices in the branch canal and off-takes to distributaries it is possible to allocate and deliver measured amounts down to the distributary off-takes. This is not possible in Dewahuwa either because of an absence of measuring devices or the inability to make use of the few existing measuring structures, or owing to a lack of adequate trained field staff. Gross figures on ex-sluice issues and areas commanded for the past seasons, however, are used by the Technical Assistant to make the deliveries to the different sections of the system.

Implementation

In implementing the plan for the wet-season rice crop, the starting date and the choice of the distribution method for land soaking and land preparation is dependent on the nature and quantity of the initial rains for the season and the amount of water available in the reservoir. Despite all efforts of the agency it has not been possible to capture the benefits of the early rains for land preparation in either scheme. A farmer-acceptable technology is yet not available for land preparation for rice on well-drained soils which makes use of the early maha rains. While this is so for maha, Dewahuwa has been highly successful in evolving a method for land preparation for other food crops during the yala season by making use of the incident early yala rains.

A staggered schedule of delivery has to be adopted for Dewahuwa between the head-end tracts and the tail-end tracts, while for Kalankuttiya this is necessary only when the head of water in the Kalankuttiya Reservoir falls below 1.5 meters (5 feet). Both schemes have the necessary design capacity for continuous or intermittent delivery of water.

During the rotational-issue period following the land-preparation phase, management problems are less difficult and rotational issues are practiced both during the wet and dry seasons in the two schemes. Depending on the nature of the water supply, rotation can be along the main canal or between tracts as in Dewahuwa, as well as between distributaries and field channels as in both schemes.

A closer adherence to the plan is observed during the rotational-issue period as compared to the land-preparation period in both schemes. Responding to rain by shutting off the system and extending the rotational interval, however, is easier to implement at Kalankuttiya than at Dewahuwa, owing to the better design characteristics and better physical conditions of structures and regulators in Kalankuttiya.

Monitoring and evaluation

In the absence of adequate measuring structures and devices in Dewahuwa as compared with Kalankuttiya, only a very rudimentary form of monitoring is done in Dewahuwa. Monitoring water supply and demand in Dewahuwa is essentially confined to the main-sluice issues. The deliveries from the main sluice are recorded by the Technical Assistant and some gross comparisons are made with the targeted water budget in the plan. No attempt is made for a quantitative comparison by evaluating the previous deliveries or planning for the next delivery. The matching of supply with demand and issues of water to distributaries and field channels is based on responses to farmer complaints of adequacy or undersupply.

By contrast, in Kalankuttiya sufficient management mechanisms are in place for monitoring and ongoing evaluation. Both at the weekly meeting of the Block Manager and his staff unit managers and field assistants, and at the monthly meeting of the Resident Project Managers and their key staff, the daily and weekly water issues at the unit level are monitored with reference to water usage, the extent of land area which uses this water, and allocation among distributary command areas. Qualitative data on adequacy and undersupply of water deliveries are also presented and discussed at these meetings.

The magnitude of variation in flows at different levels of the system for Dewahuwa and Kalankuttiya is shown in Table 2. It is observed that the Kalankuttiya System has a lower flow variation at the head of distributary channels when compared with Dewahuwa. This high order of variation in flows in turn reflects the unreliability of supply at the field level.

The big gap between planning and implementation observed in Dewahuwa as compared with Kalankuttiya could be attributed to poor maintenance, lack of functional flow-regulating and measuring facilities, insufficient agency staff, and poor communication between agency staff and farmers.

ON-FARM IRRIGATION PRACTICES

Despite the considerable improvement of on-farm irrigation practices recommended for other food crops in research by the Department of Agriculture at Maha Illuppallama, most farmers in both schemes practice very rudimentary on-farm irrigation methods which are not efficient in terms of water use. It has not been possible within the scope of this study to find out the reasons for the big gap between extension recommendation and what the farmer actually practices. It is also surprising that in Kalankuttiya, which is almost adjacent to the Regional Research Center of the Department of Agriculture, Maha Illuppallama, a majority of farmers adopt the most rudimentary flush flooding method within a basin. In Dewahuwa, however, a higher proportion of farmers are testing and adapting a range of on-farm land shaping and irrigation methods in the form of broad ridge-and-furrow, ridge-and-furrow, or furrowed basin. Quicker and more uniform wetting is achieved under these conditions and the farm stream can be handled more easily without causing much soil erosion.

Table 2. Variation in water delivery at various levels of the system for Dewahuwa and Kalankuttiya, 1985-1986.

Season	Delivery points[a]	Number of observations	Mean delivery (mm)	Standard deviation	Range (mm)	Coefficients of variation
Dewahuwa						
1985 yala	DC	5	686	302	310-1228	44
	DT	14	661	306	301-1321	46
	TO	3	474	172	240-652	36
1985/86 Maha	DC	7	1087	171	766-1373	16
	DT	20	956	448	339-2050	47
	TO	17	1129[b]	515	438-2571	46
1986 yala	DC	9	1030	355	412-1809	34
	DT	20	703	394	190-1846	56
	TO	10	570	227	313-1018	40
Kalankuttiya (Mahaweli H)						
1985 yala	DC	3	886	96	880-1006	10
	TO	11	755	128	624-1037	17
1985/86 maha	DC	5	688	99	513-797	14
	TO	28	534	192	104-859	36
1986 yala	DC	5	907	100	766-1022	11
	TO	29	757	259	167-1223	34

[a]DC = Head of distributary channel.
DT = Direct turnout from main canal.
TO = Turnout from DC.
[b]Increased by inflow from local runoff.

Source: Miranda, S.M.; IIMI Irrigation Management for Crop Diversification Group (1988).

CROP DECISION-MAKING CONSIDERATIONS

Although a major part of the cropping decisions are made at the pre-kanna meeting, deviations from these decisions are not uncommon in both schemes, especially the extent planned and actually cultivated with rice in the yala season. Bethma farmers, in particular, are able to make their decision only after they know the location of their farm lot within the allotment, its soil and drainage quality, and its access to irrigation supply. Although the drainage class of the soil has a significant influence on selecting land for either other food crops or rice during the yala season, it is not the sole criterion. In the tail end of the longer field channels where water supply tends to be limited, farmers are able to raise other food crops on imperfectly drained soils, and to some extent even on poorly drained soils. In Kalankuttiya, around 30 percent of imperfectly drained soils are planted to chili by provision of simple on-farm drainage. Where farmers are certain of the water supply they choose a crop such as chili which gives a higher return.

Market profitability as well as experience in growing other food crops influences farmers' cropping decisions. In both schemes farmers give preference to chili because of higher returns and an assured market. There is a significant extent of soybean and green gram grown in Dewahuwa, however, because water supply for the longer-duration chili is not as certain as in Kalankuttiya. Availability of credit is also an important consideration in growing chili because the cash costs involved is about three times that of rice.

CHAPTER 5

Operational Research For Testing Management Innovations

INTERDISCIPLINARY STUDIES CONDUCTED over three seasons commencing yala 1985 led to the identification of the following three important constraints to diversified cropping:

1. Unreliability and inequity of supply at the turnout level arising from inadequate control and regulation, especially at the secondary and tertiary levels of the irrigation system.

2. Lack of organization and management for sharing water from the secondary level downward.

3. Poor communication between agency and farmers on water-delivery scheduling.

Arising from the above, an operational research activity was designed with a view to pilot-testing some appropriate management innovations in close collaboration with staff of the management agencies at the two field research sites in yala 1987.

OPERATIONAL RESEARCH ACTIVITIES

In Dewahuwa, the two field channels and direct turnouts located within Distributary-D1 of Tract 3 were selected for the operational research study, with Distributary-D2 of Tract 3 as the control. In Kalankuttiya, Distributary-305-D4 which has five field channels was selected for the study, with Distributary-305-D2 as the control. The following operational research activities were conducted.

* Flow measurements were monitored at the main or branch canal at the offtakes to distributaries, and to turnouts to field channels and direct offtakes, both during day and night for each rotational issue.

* The computed water delivery for each rotational issue at the respective turnouts was fed back to the project management prior to each subsequent rotational issue. This enabled the management to obtain a proper estimate of either undersupply or oversupply at the turnout for the duration of each delivery, and to use this information for taking appropriate corrective measures at the subsequent rotation.

* The management staff was assisted by IIMI field research staff in the interpretation and use of the flow data so that they could improve the equity of supply to turnouts in each successive rotation.

* The process by which the agency staff interact with designated farmer representatives in explaining the results of the flow data and the follow up in making improvements or modifications were closely observed.

* The flow of information from agency staff to farmer representatives and farmers, and the communication processes between agency and farmers were also followed and observed.

RESULTS OF INTERVENTION STUDIES

Dewahuwa

Water-flow information

Just prior to the kanna meeting for yala 1987, the water-flow data of the past three seasons gathered by IIMI were presented to the Technical Assistant in a form that enabled him to get an overall picture of the behavior of the conveyance and distribution system, and the state of oversupply or undersupply within different parts of the system. The project management was thus able to relate the quality of its past decisions to a set of quantitative figures, and thereby base their management decisions for the season of yala 1987 on a set of more objective data. This was of special significance during this season because even farmers themselves were initially not very enthusiastic to undertake a very restricted bethma cultivation owing to the severely restricted water supply in the reservoir.

The project management effectively used and interpreted the past data with the help of IIMI staff and was able to propose to the farmers and obtain their acceptance for a restricted cultivation of one-sixth the command area for this yala. The availability of this minimum set of flow data also enabled the project management to enforce the use of rainfall for land preparation without farmers having to wait for irrigation issues. A total rainfall of 172 mm was received during the land-preparation period. The first water issue was given only on 10 May by when most farmers had completed their land preparation and had planted their crops except in Field Channels 1, 2, and 3 which had problems more due to excess rain, poorly drained soils, and delays in obtaining their bethma portion of land. In yala 1985 and 1986, issues for land preparation from April to May amounted to 174 mm in 1985 and 121 mm in 1986; there were no water issues for land preparation in yala 1987.

In the previous seasons, issues of water for each rotational issue were made on the basis of providing a 75-mm duty ex-sluice for the extent under cultivation. The duration of each rotation was decided by the Technical

Assistant. The pattern of delivery to the different sections of the system was also determined by the Technical Assistant as best understood and judged by him. Farmers generally agreed with the decisions made by him and there was little or no need for developing a meaningful dialogue and discussion between the project management and farmers on how to bring about improvements in the delivery schedules and amounts. The past three seasons of water-flow data gathered by IIMI again provided an objective basis for improving the delivery schedules during yala 1987.

The water-flow data for each rotation proved to be a very effective focal point for discussions between project management and farmer representatives at the fortnightly meetings of the Tract Committee, as well as in the informal meetings that were held prior to each rotational issue. A very clear and convincing instance was that after the fifth rotation on 2 July, where the water-flow data from the fourth rotation of 21 June was used as the main basis for explaining and obtaining the agreement of the farmer representatives to change the schedule of delivery from the head-end section of Tract 3 to the tail end during the first one-and-half days of the three-day delivery schedule. This should be viewed against the farmers' initial proposal of extending the duration of each rotation from three days to four days, and at the same time, retaining the schedule of delivery to the head end in the first two days.

Within the course of this season it was becoming evident that the regular discussions between agency staff and farmer representatives prior to each rotation, and which centered around the flow data, were evolving into an effective tool in farmer-agency cooperation and decision making. Farmer participation in decision making along with the agency staff was also considerably enhanced as a result of these meetings which were mainly centered around the water-flow data.

As seen in Table 3 the supply to both distributary- and field-channel turnouts within Distributary-D1 has stabilized from Rotation 3. The values shown for Rotation 7 are for a seven-day rotational interval. If these figures were calculated for a ten- or eleven-day rotational interval, the value would then be very similar or equal to those of the other rotations. When the weighted mean delivery of Distributary-D1 is compared with Distributary-D2, a saving of nearby 15 percent of water is realized in D1 as compared with D2 which was the control in this study. This is a very significant saving in a season as dry as yala 1987.

Table 3. Water issues (mm/day) for Tract 3, Distributary-D1, and turnouts within it compared with Distributary-D2 (control).

Rotation	1	2	3	4	5	6	7	8
Period	10 May-30 May	31 May-10 June	11 June-20 June	21 June-01 July	02 July-11 July	12 July-21 July	22 July-28 July	29 July-10 Aug
Number of days	21	11	10	11	10	10	7	11
Evaporation (mm/day)	6.2	7.0	6.8	5.5	7.2	6.9	8.3	6.7
Rainfall (mm/day)	8.2	-	-	0.6	-	-	-	1.0
Main canal	2.6	6.6	8.4	7.6	9.4	8.9	13.9	8.2
Other food crops - 185 ha								
Rice - 17 ha								
Distributary -D1	3.8	8.6	10.9	9.5	12.1	9.5	16.0	9.1
Field Channel-1	1.6	3.1	4.4	3.0	4.0	4.4	7.6	2.7
Field Channel-2	3.5	7.5	10.7	10.5	10.0	12.5	22.0	12.9
Field Channel-3	2.4	6.2	9.0	9.0	7.5	9.2	19.6	9.2
Field Channel-4	2.0	3.3	4.5	4.4	10.9	8.5	21.2	14.0
Distributary -D2	5.0	10.0	19.1	15.5	9.1	11.3	13.0	11.2

Source: Various IIMI reports (1987).

The low supply to Field Channel-1 in all rotations can be partly explained by the significant amount of seepage that takes place from the adjacent distributary channel which is located in a very porous quartzitic soil. The high supply to Field Channel-2 is essentially due to both bad maintenance of the channel and poor control and regulation within this channel where the gates and drop structures are in disrepair.

It is clear that while collaboration between the project management and farmer representatives has been effective up to the turnout level in the system, it is less so below the turnout levels. Management problems below the turnout level are essentially more complex and are further complicated by the nature of the bethma that was practiced during the season where five farmers had to share a two-hectare (five-acre) allotment. Despite this, the number of cases of interference with farm outlets belonging to others has markedly reduced in this season. This could be attributed to a better reliability of supply and improved communication.

Agency-farmer management interaction

The basic management principle underlying operational research during yala 1987 in Dewahuwa was information feedback to farmers and project officials, and *between* farmers and project officials. The information included water measurements of flow and duration, deviations from the intended pattern, and the attitudes of farmers and farmer representatives.

The primary mechanism to provide farmers and agency staff with feedback on their irrigation management performance was post-issue meetings involving farmer representatives, the Project Manager, the Technical Assistant, and IIMI Research Assistants to discuss the previous issue, and plan the next issue. These meetings were supplementary to Tract Committee and Project Committee meetings which also brought together farmer representatives and project management on a regular basis.

A key innovation introduced by the Project Manager during yala 1987 was to give farmer representatives responsibility for controlling turnout gates, which in the past was handled by the irrigator. The role of IIMI Research Assistants in monitoring water flows and farmer attitudes combined well with the Project Manager's interest in monitoring the performance of these farmer representatives in fulfilling their new responsibilities.

The post-issue meetings of farmer representatives and project management were valuable for exchanging information while the previous issue was fresh in their minds, and in planning for the upcoming issue. The close interaction among the farmer representatives, the Project Manager, and the Technical Assistant that was facilitated by IIMI Research Assistants, helped the farmer representatives carry out their water-distribution tasks effectively.

Kalankuttiya

Water-flow information

Faced with an entirely new situation at the beginning of this season where only the well-drained portions of turnouts were to be permitted a bethma cultivation, the delivery schedule and the supply to each turnout had to be considerably modified from those of the previous seasons. The flow data of the past three seasons were effectively used in proposing an appropriate rotational schedule to fit into the new situation where only parts of turnouts were to be cultivated during this season.

The rationale of this new delivery schedule to distributary and field channels was explained to the Irrigation Engineer, Kalankuttiya, who found it readily implementable from the sixth rotation onwards, and he was able to implement it successfully for all 20 distributaries in the branch canal as well as for the 5 turnouts within 305-D4. A major change from the previous seasons' delivery pattern was that in place of simultaneous flow in all five field-channel turnouts during the usual four days of flow, a more rational approach which ensured a minimum one-cusec flow for a period of one to two days for each turnout depending on the number of allotments within each turnout was proposed.

As seen in Table 4 the degree of variation in the supply to turnouts has considerably reduced from the sixth rotation onwards. An improved stability in supply has been achieved by the proposed delivery schedule. During yala 1986, the amount of supply to turnouts was in the range of 2 to 12 mm/day per delivery in 305-D4. This was, however, in a situation where both rice and other

Table 4. Water issues (mm/day) for 305-D4 and its Turnouts 1 to 5 (intervention distributary) compared with 305-D2 (control distributary).

Rotation	1	2	3	4	5	6	7	8	9	10	11
Period	9 May-14 May	15 May-20 May	21 May-24 May	25 May-2 June	3 June-11 June	12 June-21 June	22 June-1 July	2 July-12 July	13 July-22 July	23 July-3 Aug	4 Aug-18 Aug
Number of days	6	6	4	9	9	10	10	11	10	12	15
Evaporation (mm/day)	4.49	4.02	4.05	4.87	4.96	5.87	5.71	6.20	4.80	5.90	5.70
Rainfall (mm/day)	4.00	13.40	0.00	3.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Channel											
Distributary -D4	17.70	5.40	10.50	7.80	10.10	6.60	8.40	8.60	10.00	6.90	6.88
Turnout 1	5.60	2.10	1.90	4.90	3.40	2.80	5.10	5.80	6.10	5.20	4.56
Turnout 2	13.70	3.90	7.40	5.60	8.70	5.90	6.70	5.90	8.10	6.00	6.24
Turnout 5	17.30	3.20	8.30	5.60	6.10	4.60	6.00	5.80	7.90	4.90	3.84
Turnout 4	10.70	1.70	9.90	3.20	5.70	4.20	6.90	6.60	8.30	5.60	4.64
Turnout 3	10.70	3.20	4.40	5.30	5.90	3.90	5.80	6.20	10.10	3.80	5.44
Distributary -D2	23.40	2.70	10.50	9.50	9.10	8.60	10.30	9.30	11.40	11.70	9.30

Source: Various IIMI reports (1987).

food crops were cultivated and there was no bethma. The amount of supply to turnouts is now between 5.0 and 7.5 mm/day, which is closer to the evaporative demand (Table 4).

Farmers readily accepted the new delivery schedules with their own modifications within a turnout. Most farmers preferred to take the full stream size of 1.0 cusec rather than a smaller 0.5 cusec as designed. On the well-drained soils an irrigation time of six to eight hours was required with a one-cusec stream whereas only two to four hours was required on the imperfectly drained soils.

Based on their experience during yala 1987, farmers were confident that they could effectively manage deliveries for other food crops on the well-drained and imperfectly drained soils; and that the poorly drained soils should be definitely left out for yala. Farmers reported that they would stand a better chance at cultivating other food crops in the present situation, where, unlike in previous seasons, no water was issued for rice cultivation.

Farmers have experienced in previous seasons that an acceptable frequency of irrigation is 1 in 7 days during the initial stage of crop establishment, 1 in 10 days during the mid-stages of crop growth, and 1 in 7 days during the last stages of crop growth.

Farmers were able to come up with a reliable and workable calendar for future yala seasons with regard to the first issue in April and subsequent rotations. There was a consensus of view that the first water issue for land preparation should be around 20 April, soon after the Sinhala New Year, and that planting should be completed by 20 May. This can be considered a major step forward for planning.

Agency-farmer management interaction

The basic management principle underlying the operational research during yala 1987 was information feedback to farmers and agency officials, and *between* farmers and agency officials. The information included water measurements of flow and duration, deviations from the intended pattern, and the attitudes of farmers, turnout leaders, and distributary-channel representatives.

Two mechanisms were introduced to provide farmers and agency staff with feedback on their irrigation management performance: i) post-issue meetings and ii) a rotational plan. Meetings were held after each water issue during the growing season, at which the Unit Manager and the Irrigation Engineer for Kalankuttiya Block met with IIMI Research Assistants to discuss the previous issue, and plan the next issue. IIMI Research Assistants provided information on water flows, farmer behavior, and farmer opinions. Towards the latter part of the season, farmer leaders also joined the meetings and expressed their views directly to project management. This interchange of information was valuable for both sides, and helped in the preparation of workable plans for the next issue with farmer compliance.

The rotational plan for water issues developed in mid-season provided farmers and agency staff alike with a clear set of targets. The post-issue meetings could then focus on the degree to which the targets were met, and the reasons for deviations. The rotational plan also provided the distributary-channel representatives and turnout leaders with clear guidelines. The result was that the distributary-channel representative played a greater role in opening and closing turnout gates than in past seasons. Because he knew the plan, he did not need to seek approval from the unit manager each time he wanted to adjust a turnout gate; adjustments to the turnout gate were made by either the distributary-channel representative or the unit manager's field assistant, with both of them following a common plan. This ensured an enhancement in the position of the distributary-channel representative (since he took on a greater role in water distribution), and a reduction in the work of the field assistant and unit manager.

The interaction of the turnout leaders and the distributary-channel representative with the unit manager and other officers is valuable for i) the feedback of information, resulting in better management, ii) the prestige accorded to the farmer leaders by associating with project management, and iii) the sense of solidarity that develops between farmer leaders and project management. The rotational plan is valuable for giving distributary-channel representatives clear guidelines so that they can take over a great portion of routine management within the distributary channel.

SOME LESSONS AND ISSUES

At the end of the operational research activity the following main conclusions could be drawn:

* *Flow measurement* constitutes an important tool in management decision making and implementation. It provides an effective focal point for discussion between project management and farmer representatives, and it can also be a useful instrument for improving farmer-agency cooperation.

* *Regular meetings between farmer leaders and project staff* (especially Unit Managers in Mahaweli System) after each water issue are an effective way to improve communication between farmers and project management, especially to identify and rectify specific water problems at the secondary and tertiary levels. These meetings also enhance the position of the farmer representative, turnout leaders, and the distributary-channel representative by giving them a highly visible function.

* *Regularly scheduled rotation of turnouts* enhances the capacity of the farmers to take over management functions below the distributary-channel gate which in turn frees the Unit Manager in the Mahaweli System to attend to other duties, and farmer representatives in Dewahuwa to schedule this time for operating turnouts and other related functions.

Apart from the above conclusions, the following issues are also posed:

* What is the most feasible and effective means by which irrigation agencies could obtain a minimum set of flow data, and how could this be sustained in the two systems now studied after IIMI staff phase out?

* How can farmers play a greater role in irrigation operation and maintenance at the secondary and tertiary levels so that water efficiency can be improved and agency staff can have more time for other duties?

CHAPTER 6

Conclusions And Recommendations

ALTHOUGH SRI LANKA has had more than 15 years' experience of dry-season irrigation for diversified cropping, there has been a lack of clear understanding of the nature of the constraints and the unexploited potentials for further development and expansion in this field. The results of the past three years' field research have helped to clarify this understanding and also provided planners and policy makers with some broad conclusions for formulating future strategies and policies. These results could be conveniently presented, *first*, as a set of general conclusions for the benefit of policy makers, and *second*, as select key findings for the benefit of senior field and management staff. The second set of findings relate to the two main components of the research conducted, irrigation systems management and crop diversification; these will be further elaborated taking into account the constraints and potentials recognized.

GENERAL CONCLUSIONS FOR CONSIDERATION BY POLICY MAKERS

1. Select for diversified cropping only those major irrigation systems which have a shortage of irrigation supply during the dry season, and which have

more than 50 percent extent covered with well-drained and imperfectly drained soils.

2. The system should be above a minimum physical condition in its delivery system that would ensure a satisfactory degree of control and regulation of deliveries at different levels of the system.

3. There is a pressing need for improved planning by the management agency in consultation with farmers for scheduling irrigation deliveries during the land-preparation phase which takes into account improved farmer-acceptable land-preparation technologies and probability estimates of different rainfall scenarios at the commencement of each season.

4. Determine for each system the best way that a minimum set of flow measurements could be made (and used operationally) during the season, and also how this could be sustained.

5. Farmers should play a greater role in operation and maintenance at the tertiary level in order to improve water use efficiency.

6. Fix a definite time schedule for commencement and termination of yala cultivation operations, and encourage a shift to 110-day or shorter-duration non-rice crops in order to optimally utilize available dry-season irrigation supply.

7. An assured and stable market, a competitive price, and a ready availability of credit are indispensable for promoting and sustaining crop diversification.

IRRIGATION SYSTEMS MANAGEMENT AND CROP DIVERSIFICATION

In the *irrigation systems management* component of the research the three main areas of study were 1) adequacy of delivery at the main, tertiary, and farm field levels; 2) underlying principles of management for scheduling and timing of deliveries; and 3) nature of operation and maintenance activities at respective levels and institutional relationships.

In the first study area of adequacy of delivery at the main, tertiary, and farm field levels, it is observed that a total ex-sluice issue of approximately 1,000 mm (3.25 feet) for the season is adequate during yala if more than 75 percent of the irrigated area is under other food crops. When the irrigated area is made up of 50 percent other food crops and 50 percent rice then a total ex-sluice issue of approximately 1,500 mm (5.0 feet) for the season is adequate. In order to ensure reliability and equity at the tertiary level of the system it is necessary to have a good standard of control and regulation at the level of the main system, and this would require both good agency management and the presence of appropriate regulation devices within the system. Furthermore, the physical system should be at a desired minimal level, both in design and in operational conditions, to meet the controlled supply needed for growing of non-rice crops or other food crops.

It is observed in the second study area of underlying principles of management for scheduling and timing of deliveries that there is a big gap between the planned quantity and timing of deliveries and their actual implementation, and this is specifically so at the land-preparation phase where much of the overrun occurs. There is, accordingly, the need for a re-examination of the present assumptions that are made with regard to water-requirement values for land preparation for puddled wetland rice and non-puddled other food crops, as well as of the presently advocated technologies for land preparation. There is also the opportunity for more meaningful statistical analysis and proper interpretation of past rainfall data with a view to fixing the most opportune date for commencement of the cultivation season, and as an avoidance of excessive rainy spells during the early establishment phase of other food crops, when soil saturation can be damaging to the crop.

Third, in studying the nature of operation and maintenance activities at respective levels and institutional relationships it is observed that the unreliability and inequity that are recorded at the turnout level are closely linked to two main factors: 1) lack of proper organization and management for sharing water below the secondary level, and 2) poor communication between the agency staff and farmers in scheduling of water deliveries. The operational research that was carried out in yala 1987 has demonstrated that flow measurements can prove to be a useful tool in decision making and implementation, and that regular meetings between farmer leaders and management staff soon after each water issue can improve communication. It has also demonstrated that regularly scheduled rotations at the turnout level greatly facilitate the farmer representatives jointly managing or taking over management along the distributary channels.

In the *crop diversification* component of the research the two main areas of study were 1) existing and potential irrigation practices at respective levels, and 2) incentives and constraints.

Existing opportunities in both Dewahuwa and Kalankuttiya schemes show that they have enough canal capacity for the desired intermittent flow for irrigating non-rice crops. In Dewahuwa, however, an improved regulation of the limited water supply during the dry season can be achieved by better utilization of the installed flow regulators along the main canal, and also by the agency operating these regulators in the proper manner. Similarly, as in the case of Kalankuttiya, the use of existing measuring devices at least at the distributary level could facilitate better allocation and distribution of water below the distributary level.

No major changes or modifications are needed in either the land or soil qualities in switching from wet-season rice to dry-season non-rice crops. The existing basins or *liyaddes* do not need any modification, although in both schemes a physical consolidation of the smaller sized basins into larger sized ones as carried out in Tracts 1 to 4 of Dewahuwa as part of the rehabilitation project funded by the Japanese International Cooperation Agency would help in improved on-farm water management. Minimum on-farm land shaping in order to enable the furrowed-basin system of irrigation for other food crops would help to reduce on-farm water use and farm labor costs of irrigation. The well-drained reddish-brown earths (RBEs) have no limitations for growing of any kind of other food crops during the dry season, and their soil physical attributes readily lend them to be alternated between wet-season rice and dry-season non-rice crops. Farmers in both schemes are evolving successful practical methods of expanding the growing of other food crops on to the imperfectly drained RBE soils by provision of minimum on-farm drainage. This trend could be further strengthened and enhanced by good water control at the field-channel level. It is recommended that the poorly drained low-humic gleys (LHGs) be restricted to rice during both wet and dry seasons for the present, with the proviso that a rice yield of not more than 2.5-3.0 tons/ha should be expected in yala when the rice crop is irrigated at the same interval and frequency as other food crops.

Kalankuttiya benefits from the management system for System H that has been devised by the Mahaweli Economic Agency. It is adequately staffed down to the turnout level and the staff are assigned a clear set of duties. By contrast, the management system at Dewahuwa is yet evolving. Its present strength of agency staff, especially the technical assistant, work supervisor, and irrigation laborers could be trained and assigned a clear set of duties and this would go a long way towards improving the management of the system as a whole. Empowering the Dewahuwa management with more authority, and a better exploitation of its institutional setup is also recommended.

Matching the planting-to-harvest duration of other food crops during yala to the availability of water supply from the source should receive more consideration than at present. In both schemes the most reliable period of water availability at the source during yala is from 1 May to 30 August. Assuming that crop establishment is completed by 10 May, this leaves a balance of 110 days for crop growth and harvest. A chili crop takes 145 days from crop establishment to completion of harvest, and the management agency in both schemes encounter considerable difficulty supplying the irrigation needs for the chili crop after August. It also adversely affects the repair and maintenance schedule which is normally planned for the period September-October. On the foregoing considerations it is recommended that the planting-to-harvest duration of the dry-season non-rice crops be restricted to a 110-day period.

When incentives for diversified cropping were considered, it was noted that the attractive market price for chili as well as an assured market were the main incentives for farmers to grow this crop in both schemes. The net returns to farm resources for non-rice crops during yala, especially chili, is very much higher than for rice as shown in Table 5. Other non-rice crops such as green gram and soybean are also more profitable than rice during yala, but the market for these crops at Dewahuwa is not so assured as chili in most seasons.

The constraints to more effective irrigated crop diversification which were observed can be grouped as irrigation related, institutional, agronomic, and economic. The irrigation and institutional related constraints are so closely interconnected that they will be discussed together; the agronomic and economic constraints will be discussed individually.

During the dry season when a limited water supply has to be delivered by rotational distribution, a greater joint management effort between farmers and

Table 5. Average cash production costs (Rs/ha) for 1986 yala season crops in Dewahuwa and Kalankuttiya.

	Dewahuwa				Kalankuttiya	
Cost item	Rice	Chili	Green gram	Soybean	Rice	Chili
Fertilizer	788	2023	40	147	804	2048
Pesticides, herbicides	181	2580	1053	381	420	2196
Seed, seedlings	406	575	807	750	671	597
Hired equipment	1323	1406	1278	1702	1930	1517
Hired labor	1345	6258	2356	2462	1432	4835
Irrigation water	7	78	0	0	56	54
Total cash cost	4050	12920	34	5442	5313	11247
Gross returns	7814	26265	12848	16863	10436	25383
Net returns	3764	13345	7314	11421	5123	14136

Source: Various IIMI reports (1986).

agency is called for, and this in turn needs improved communication between the two parties. Changes in delivery schedules are often not communicated properly to farmers and the reliability of water delivery is thereby hampered. Farmers are reluctant to grow high-value other food crops like chili which involve a higher cost of production if there is no regularity and reliability of supply at the appropriate irrigation intervals. A further complicating factor in Dewahuwa is that the irrigation control and measurement devices which are necessary to deliver the required intermittent water supply are inadequate and nonfunctional when compared with Kalankuttiya. The loosely structured nature of the institutional setup below the Tract Committee in Dewahuwa does not enable good communication between the agency and farmers which results in an irregularity in management decision making, leading to unreliability and inequity in water distribution.

When compared with Kalankuttiya, the quality of flow monitoring in Dewahuwa is totally inadequate. There is a lack of essential data on flow information at different levels of the system which is considered indispensable for discussion and decision making between the agency and farmers. Dewahuwa's monitoring program is limited to the reservoir and main-sluice level which, though adequate for macro-level administrative requirement, is quite inadequate for irrigation management at the lower levels of the system. An effective flow-monitoring program could, however, be developed for Dewahuwa by making use of the existing physical facilities and providing short course training to the present management staff of the scheme.

It is difficult for the management agency to make the farm lot allocation for bethma farmers when an allotment straddles both well-drained and poorly drained soils. A problem is also created by farmers who grow rice on well-drained soils which adversely affects the soil drainage conditions in the adjoining farmer's lot which attempts to grow other food crops. The Sinhala New Year festivities which fall during mid-April also act as a constraint to timely preparation of land in mid-to-late April which is the ideal time for land preparation for other food crops. Farmers in Dewahuwa have been successful in exploiting the early yala rains for non-puddled preparation of the land for other food crops, whereas in Kalankuttiya where water supply is available for both rice and other food crops, farmers delay land preparation until the heavy rains in April are over.

In respect of agronomic constraints the increasing incidence of chili leaf curl virus diseases in Kalankuttiya and the yellow mosaic virus of green gram at Dewahuwa need early attention. A wide range of other food crops are grown in Dewahuwa during yala such as chili, soybean, green gram, bombay onion, and also some vegetables. The optimum irrigation frequency for each of the above crops ranges from 2 to 10 days, whereas the irrigation frequency is fixed at once in 7 or once in 10 days at Dewahuwa. Growing these crops side by side in adjacent fields which are supplied with a common source of water raises many problems which are not adequately considered at the planning stage of the season.

With regard to economic constraints it is observed that there are greater economic risks that the farmer has to take in the cultivation of non-rice crops when compared with rice. Cash and labor inputs for cultivation of other food crops, especially chili, are three to four times higher than for rice in both schemes as shown in Table 5. It also shows that the cash inputs required for fertilizers, pesticides, and hired labor for weeding and harvesting are much higher for chili.

It is also observed that there are situations in both schemes where despite soil conditions being adequate and market conditions also favorable, not all farmers grow other food crops, particularly chili. Some of the reasons for this include availability of credit, labor availability, and land tenure. After soil and water, availability of credit appears to be the most important determinant in farmers' crop decisions. Institutional or bank credit is not equally available to all farmers and especially to those who have defaulted on previous loans, while noninstitutional credit carries interest rates as high as 20 percent per month. Recognizing that chili cultivation requires 3-4 times as much labor as rice, the size of holding, the household pool of labor and sufficient financing for hired labor will all influence the area for chili that a farmer would allocate within his allotment. In Dewahuwa, bethma farmers who are allocated land far away from their own fields are more likely to grow rice which can grow with less attention than chili.

Compared to rice, the lack of an organized marketing structure for other food crops and unstable prices tend to increase the risks for farmers who grow these. There are indications, however, that farmers who had grown good crops of soybean in Dewahuwa are quite ready to shift to other food crops if they are assured of a market and stable prices.

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