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IRRIGATION MANAGEMENT RESEARCH IN SRI LANKA
A REVIEW OF SELECTED LITERATURE

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Summary: This Occasional Paper reviews literature in four topic areas of relevance to Sri Lanka: system operations and performance, organization and management of irrigation systems, rehabilitation and modernization of irrigation systems, and resource generation and mobilization. A review on crop diversification issues is included as an Appendix. Most of the literature reviewed concentrates on large irrigation schemes and focuses on literature published since 1978. The paper attempts to identify, for each of the four topics, the progress made and lessons learned, and to suggest research questions that ought be addressed.

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IRRIGATION MANAGEMENT RESEARCH IN SRI LANKA: A REVIEW OF SELECTED LITERATURE

Douglas J. Merrey, P.S. Rao and Edward Martin*

INTRODUCTION

The International Irrigation Management Institute (IIMI) is collaborating with Sri Lanka's Irrigation Management Division (IMD) and the Irrigation Department to carry out the research component of the Irrigation Systems Management (ISM) Project. The ISM Project is being implemented with assistance from the United States Agency for International Development (USAID). Its purpose is to strengthen the capacity of the IMD and Irrigation Department for rehabilitating, operating, and maintaining major irrigation systems on a sustained renewal 'basis, with particular emphasis on strengthening farmers' organizations under IMD's Integrated Management of Major Irrigation Settlement Schemes (INMAS) being implemented on 35 major irrigation schemes. In order to achieve its objectives, the Project is supporting the rehabilitation of a numher of major irrigation systems, training and institutional strengthening efforts, farmers' organizations, and applied research.

IIMI, with USAID funding support, is assisting in the planning, design, implementation, and interpretation of the research component of the project. The objectives of the research component are to do applied research to solve problems facing efforts to improve irrigation management, particularly under ISM, and to strengthen the capacity of selected national research organizations to carry out such applied research in collaboration with relevant agencies. Thus, under this project. IIMI does not carry out field research; rather it works in close collaboration with the national research organizations to develop appropriate research proposals and help to carry out the research; and it works closely with the government agencies represented on the ISM Research Advisory Committee. chaired by the IMD Director, to evaluate research proposals, and interpret and make use of the results.

At its first meeting, on 14 September 1987, the Research Advisory Committee requested IIMI to carry out a research literature review to identify what has been learned to date, and what research questions emerge from that literature. This was a very useful suggestion since to our knowledge there has been no such review in recent years, despite the proliferation of irrigation management rescarch. This paper reports the results of that review. It is not intended to be comprehensive, either in terms of covering all topics or in terms of covering all the literature on particular topics. Rather, the review focuses on a few particular topics relevant to the ISM Project, and more broadly, to improving performance of major irrigation systems in Sri Lanka; and it attempts to identify the major works on the chosen topics.

This paper reports on: 1) system operations and performance, 2) organization and management of irrigation systems, 3) rehabilitation and modernization of irrigation systems, and 4) resource generation and mobilization.

The paper does not cover literature on village irrigation or on agricultural issues; the former is outside the purview of the ISM Project and the latter is not an integral part of its research componeni. However, IIMI has recently reviewed literature on crop diversification issues and that review is included as an Appendix. The paper also pays minimal attention to the literature on Mahaweli issues, except where particular works were thought relevant to the problems faced by the IMD and the Irrigation Department.

Most of the literature reviewed here -- and indeed most of the available literature -- concentrates on the larger irrigation schemes. A major gap in the irrigation management literature in Sri Lanka is the area of medium sized irrigation systems, those that are roughly over 80 hectares (ha) but under 1,000 ha. There are about 250 such schemes, 223 of which are under 600 ha (Perera 1986): they constitute nearly 80 percent of all the systems above 80 ha in size, though only about 21 percent of the total irrigated area under schemes having more than 80 ha.

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We focus on literature since 1978, the year of Chambers' (1978) influential overview of water management issues in Sri Lanka. Chambers noted the paucity of work on irrigation management questions, particularly in the Dry Zone. Since 1978 there has been a large volume of writing, some based on field research. The next landmark was the 1982 workshop at the Agrarian Research and Training Institute (ARTI). Although the Proceedings did not appear until 1986 (Abeyratne, Ganewatte, and Merrey 1986), that workshop brought many researchers and agency officials together and demonstrated that much interesting work was already under way. Some of the results went against prevailing assumptions, sparking lively debates during the workshop.

In 1985, Wimaladharma (1985a) edited a volume containing a series of articles by officials on various aspects of irrigation management in settlement schemes with particular reference to the IMD's INMAS program. Although not based on research, these provide a good overview of the official point of view on how things are supposed to work. Wimaladharma (1985b) has also published a comprehensive bibliography of 360 entries on irrigation and water management issues in Sri Lanka, demonstrating a remarkable explosion of writing on the subject. This bibliography remains an important starting point for any rescdrch on irrigation management topics in Sri Lanka.

In 1986, the ARTI hosted a seminar on irrigation management and agricultural development, whose paper abstracts have been published (ARTI 1986). A comparison of the quality and range of coverage in this seminar with the 1982 seminar (Abeyratne et al 1986) demonstrates the progress made in irrigation management research since then. ARTI began publishing a quarterly irrigation management newsletter called *Diyawara* in 1986. This carries short articles. summaries of larger works. and news on papers and publications. and is thus a useful source of work currently underway.

Some of the literature reviewed here is not "research" in a strict sense. One interesting aspect of the irrigation management literature in Sri Lanka is the extent to which officials themselves have written of their efforts to come to grips with the problems they face, their experience, and their reactions to research done hy others. Some of thir literature has been included here since it often contains very useful insights. and much of it is based on practical experience.

The paper attempts to identify, for each of the four topics, the progress made and lessons learned. and to suggest research questions that ought be addressed. The authors hope that it will generate discussion and feedback as well. We would like to hear from those who note any errors of omission from the literature reviewed or errors of commission where we may have misinterpreted or misunderstood the literature: and we welcome general critiques of the paper and suggestions for improvement for the future.

IRRIGATION SYSTEM MANAGEMENT

The literature reviewed represents the experience of a selected number of projects in Sri Lanka in the broad area of system management. It is by no means exhaustive but provides a reasonahle picture of the nature of the problems addressed in various projects. The cases include Gal Oya. Kaudulla. Mahaweli, Mahakanadarawa. and Inginimitiya.

TIMP Mahakanadarawa Tank

Choo and Senthinathan (1986) describe the planning for introducing rotational irrigation in the Mahakanadarawa Tank of the Tank Irrigation and Modernization Project (TIMP) in *maha* 1980/81. A major objective of TIMP was to introduce water saving irrigation practices such as 1) early dry sowing using early rainfall in maha, 2) cultivating rice varieties with short growing periods, and 3) rotational water distribution. Maha 1980/81 was a particularly difficult year with unusually low rainfall and only five water issues were made between December 29. 1980 and February IS, 1981.

The preparation of water delivery schedules and operational guidelines for introducing rotational distribution.

practices, training of farmers and officials of the Irrigation Department, the organization for the O&M of the system, and the problems of conveyance of water in a canal passing through four or five minor tanks are described in detail. The farmers are reported to have been generally cooperative and to have tried to follow the new water schedules when they developed confidence in the system. Particularly, the farmers of the tail end areas were encouraged by the equitable water supply.

The paper makes ten recommendations for water management based on the maha 1980/81 experience at Mahakanadarawa. These include improving the main canals through by-passing minor tanks and double banking the reaches passing through depressions, lining where serious leakage occurs, and the absorption of the private farms irrigated from the tank and providing them with on-farm irrigation facilities to practice rotational irrigation on the same basis as the farm lots of the project.

Mahaweli System H

Gunathilaka (1986) describes the water management practices adopted in the newly developed lands under Kandalama, Dambuluoya and Kalawewa reservoirs in the Mahaweli H area. He describes the channel systems, the control devices adopted, the originally proposed water distribution system as per the designed weekly water requirements, and the operational staff and their responsibilities. He also describes the practical difficulties in actual operation, as the cultivation calendar is not followed by the farmers for a variety of reasons.

The author mentions that farmer education helps proper water management but by itself will not reduce over-consumption of water. In the absence of a system of water charges based on volume of water, he suggests that a farmer has no incentive to reduce his consumption of water. The problem of motivating the field assistants, the importance of having accurate measuring structures and gates, and the need for better methods of communication such as radios and telephones are discussed. The author emphasizes the need to deal decisively with the minority of farmers who break the law by taking legal action.

An evaluation of the performance of water control structures was made in the early 1980s in representative turnout areas in several irrigation projects including Mahaweli System H, Mahakanadarawa, Kaudulla and Minneriya. Corey (1986) reports on the results of the evaluation, with special emphasis on the water control procedures in Mahaweli System H. In this system, detailed observations were made on all of the structures within seven turnout areas and less complete observations in several other turnout areas.

Corey (1986) makes several critical observations of the water control situation in the seven turnout areas. These include:

1. Not one of the weirs installed for the measurement of flow in turnouts was usable. The elevations of most of the turnouts were too low to permit weirs to operate normally;

2. Out of the 83 allotments receiving water, only 40 received it through authorized project outlets;

3. Boards for controlling water flow at the outlets were not being used;

4. Concrete in the farm outlet head control structures was of very poor quality. Many of the structures were crumbling, cracking, or both;

5. Many of the original farm outlets were placed at too low an elevation to permit irrigation of the land intended to get water from these outlets;

6. Rotation of water distribution, where practiced at all, was done in a haphazard manner with little supervision. Farmers at some of the turnouts tried to use a continuous flow system rather than a rotation. The turnouts at

the upper positions of ditches removed too much water from the ditch when continuously open especially when enlarged by farmers. Adequate supervision to close these outlets was lacking;

7. Of the 83 allotments receiving water from one distributary. 33 were operated (during that year) by renters and not owners of the land:

8. Maintenance of structures, as well as ditches and access roads, was virtually always poor;

9. The problem of water supply for the system as a whole was being aggravated by the practice of issuing water to the turnouts for land preparation. The farmers were using too much water for ploughing and the "mud plastering" of bunds.

Corey (1986) reports that the continuous flow system was working more smoothly in the older systems (Kaudulla and Minneriya) than in Mahaweli System H mainly because the farm outlets were designed for continuous flow [i.e. 3 inch (7.6 cm) rather than 6 inch (15.2 cm) diameter pipes]. However, the lack of discipline among farmers due to renters and encroachers was very much in evidence.

The turnout structures for the Mahakanadarawa project were modernized two years prior to this study. The system operation and water distribution seemed to have improved considerably after modernization. The author believes that this experience could be profitably adopted elsewhere.

Gal Oya System

Widanapathirana (1984) describes the Gal Oya Left **Bank (LB)** water management data for the 1983 *yala* season. ARTI was involved in some aspects of the Gal Oya rehabilitation project. Two of these aspects were evaluation studies and monitoring the effects of the changes resulting from rehabilitation work, and research on water management. For this purpose, ARTI had been conducting a continuous farm record-keeping exercise for selected farmers in the left hank of the Gal Oya scheme since the 1979/80 maha season. The presentation of such data in summary form seasonally is useful for evaluation studies. This report for the yala cultivation in 1983 is the first of a series of such presentations by the ARTI. Data on reservoir storage and land authorization, water issues, rainfall, planning and staggered cultivation, resource use characteristics. and agricultural production supplemented with important aspects relating to systems operation are included id this report.

The system of water delivery throughout the yala season was rotational after a continuous water issue for the first 23 days. In addition to one issue for land preparation and planting, there were nine individual rotations whose duration varied from two days on - four days off to I3 days on - seven days off during the season. Not all the rotation schedules were conveyed to farmers in advance. **As** a consequence. there was some dissatisfaction among farmers in various areas of the scheme.

The average (unweighted mean of a sample of 315 farmers) yield per acre in Gal Oya **LB** was 53 bushels (2.75 tons per ha). The cost of unmilled rice production per acre based on a sample of 270 farmers was Rs 2,234 (Rs 5.518 per ha) excluding family labor cost and Rs 3,059 (Rs 7,556 per ha) if family labor cost was included.

The report provides a useful summary of water deliveries and agricultural production for one season.

The paper by Wijayaratna (1986a) is a preliminary analysis of data based on the Gal Oya **LB** system pre-rehabilitation studies conducted by ARTI and Cornell University. The data collection scheme and the development of a Water Availability Index (WAI) are described. The paper focuses on the specific objectives of: a) the increased involvement of farmers in allocation, control and maintenance; b) improving the equity of water distribution; and c) increasing its reliability of timeliness all of which are of prime importance in water management.

Some aspects of the past performance of the system are described. Important causal factors for uneven distribution of water are grouped under two heads, complexity of the system and physical constraints, and constraints related to resources and behavior of the participants (operators and users).

Two inter-related questions are addressed in discussing the implication of selected factors on system rehabilitation and modernization: are system operators actually able to control water at all levels in the system as intended; and can they reasonably delegate some of the responsibilities of management to the "users"?

Four findings are discussed in answer to the above questions:

1. The nature of system deterioratinn (especially the rate at which it has occurred) and its "status" at the given time call for active involvement and collaboration of both the farmer and the irrigation bureaucracy at all stages. namely that of design, constructinn. and subsequent operation and maintenance (O&M).

2. Active participation of the users in system managrment is necessary because of the disparity between the "planned" and "actual" command area and increase in the number of operators and operational holdings.

3. Investigations of the time sequence of cultivation operations on individual farms in the Gal Oya LB system indicate the need for delegation of some system managemrnt responsibilities to farmers.

4. Inadequacy of resources available to the system operators (given the channel configuration of the LB system) also calls for delegation of system management responsibilities to the Farmers.

In his Ph.D. thesis. Wijayaratna (1986b) takes his research on the Left Bank of Gal Oya much further. The objective of this study was to "conceptualiz- · nd develop an analytical framework to assess the impact of improved water management on the production performance of an irrigation system" (see Wijayaratna 1986b:10, 256). Although the rehabilitation program began in 1980. actual restoration of the physical system was delayed by two to three years. Hence the analysis in this study represents the pre-rehabilitation situation. Based on research from 1980 to 1982, the WAI concept is developed further and refined; this is based on daily observations of water status on a large sample nf paddy fields. broken into the vegetative and flowering stages, and recombined. A close positive correlation of yield and WAI is shown

Analysis of the pattern of distribution of water over time and space on the LB reveals significant variations in WAI among seasons. within subsystems of the left bank, and among farms within subsystems. Using a "nested model" of the system. Wijayaratna found that there was a greater degree of variation in water supply between head and tail of subsystems (branch canals) and of distributary channels operated by the Irrigation Department than at lower levels of the system managed by farmers. There was also a large variation in water supply among subsystems. Since the main system contributes so much of the total variability in water distribution, and the magnitudes of variation are so much higher at this level, he concludes that reallocation of water at the subsystem and distributary channel levels would have the greatest impact on yields.

Wijayaratna uses a number of sophisticated analytical tools to estimate the yield gap -- the gap hetween actual and potential yields -- and the contribution of water to this gap. These methods of analysis show that aggregate yields could he increased significantly through rearranging water distribution. with no significant impact on yields in water abundant areas. Since about 40 percent of the yield gap is due to water, and the balance due to other factors. it is shown that although the rehabilitation of the system alone may he insufficient to increase yields significantly unless other factors are also addressed, improved water distribution would probably have an interactive impact. so the rehabilitation and efforts to improve management are more than justified.

Kaudulla Studies

Goonasekera (1985) studied the case of Kaudulla irrigation scheme and its water management for his Ph.D. thesis. Based on several seasons' research at Kaudulla Scheme (Stage I), this is an attempt to be more comprehensive than an engineering study. The study reports on observations of problems in the scheme, measurement of irrigation system performance, and the socio-economic context and roots of the problems (with assistance from a sociological study reproduced as an Appendix). with particular emphasis on problems within the administration (Irrigation Department). Goonesrkera examines various alternative arrangements for improving the system by creating a greater sense of accountability for system performance, and introducing financial autonomy and viability and farmer responsibility with the state as behind-the-scenes benefactor and beneficiary.

Some specific findings include unreliable and inadequate water supplies to the tail end, the result of severe deterioration of the physical system (inadequate controls, erosion and siltation of channels), as well as design problems (such as long channels). Poor maintenance was related to insufficient funds for maintenance. Serious water problems were experienced by 20-30 percent of the farmers. A hreakdown in institutions essential for the engineering system to function was identified as the major constraint causing irrigation difficulties and social inequalities at Kaudulla. While rehabilitation is feasible it can he justified economically only if the institutions for O&M are strengthened. ·To do this, motivation of managers, generation of finances from the system for maintenance, farmer organizations. and elimination of political constraints will be required..

Goonesekera's suggestions include: the need to develop more effective institutions for system management, including at community level; the need to generate resources for maintenance of the system since the national economy cannot do this (he gives figures to show that if current O&M fees arc collected, they would he three times the present funds given by government for maintenance). He also shows that the evaluation of system performance. especially with limited resources, is very difficult.

Some research recommendations include: the need to develop low cost electronic devices for flow monitoring; the need to develop an effective irrigation management extension service: the need for long term research efforts to evaluate the reasons for low productivity: the need for research into institutional and organizational aspects. farm level reuse of drainage, design of effective and economical flow control structures (including why present designs sometimes fail), alternative irrigation system layouts and management practices to promote cultivation of other field crops, and how to redesign old systems economically.

Another major study of irrigation water management at Kaudulla was done by the Overseas Development Unit of Hydraulics Research, Wallingford, UK in collaboration with the Irrigation Department, A report by Ahernethy (1985) reviews the measurements made during 1978-83 and, based on a detailed analysis. makes proposals for new management methods. There was also a series of interim reports prepared between 1979 and 1985 while the study was in progress. referenced in Abernethy (1985). A second report (Abernethy and Weller 1987) discusses the work that was continued for a further two years (1983-85) and deals with the water distribution within small-scale farmer groups in selected tracts. The Kaudulla study and its two reports represent a major contribution to the understanding of the performance, operations and the management of an irrigation system Major findings of these reports are briefly reviewed.

Abernethy (1985) presents a concise factual review of the situation in Kaudulla. identifies the lessons learned from the measurements. and on the basis of these. develops a proposal for a new set of management procedures in which a micro-computer would he used to assist decision making.

System efficiency. The field measurement program aimed to discover·how much water was available to the system, and how it was being distributed within the system. How much water do the crops at Kaudulla need? There was little variation from year to year in potential evapotranspiration (Et). The maximum is 0.272 inches/day (6.9 mm/day) in August and the minimum 0.134 in/day (1.4mm/day) in December. The overall efficiency of the system, meaning the proportion of all water issued from the **tank** sluices that is eventually used by the plants, was 42.9 percent in yala, and 25.6 percent in maha. The system makes little use of direct rainfall. The area cultivated tends to be less by about 20 percent on average in yala than in maha. Even though rainfall in maha is four times more than in yala, and makes an additional 28,000 acre feet (3,453 ha meters) available, there is no reduction in tank issues, which average 38.083 acre feet (4.697 ha meters) in yala and 39.625 acre feet (4,886 ha meters) in maha.

Crop water requirements in both seasons are about the same at 19,324 acre feet (2,383 ha meters) in maha and 20,031 acre feet in yala. Thus the water budget shows that the main deficiency of the system is in its inefficient utilization **of** rainfall. During the period **of** the study. savings of the order of 20,000-24,000 acre feet (2,466-2,959 ha meters) were achieved in the maha season by the combined effect of earlier planting and rotation of issues. There is relatively little scope for improvement in the other losses. which do not seem unsatisfactory at their present level.

RWS and productivity. The Relative Water Supply (RWS the ratio of water supplied to the crop requirement) as issued from the tank sluices, is in the range of 2.5-3.1 in the maha seasons and in the range of 1.3-2.4 in the yala **seasons.** The supply is inadequate in at least some yala seasons. The RWS at the tank sluice should be about 2.0 for adequacy.

As to productivity, yields varied from 2.1 tons/ha to 5.8 t/ha. The average yield in maha is 3.93 t/ha and corresponds to a productivity value of 0.252 kg per cubic meter of water supplied at the tract.

Inequality. The question of inequality in the distribution of water received considerable attention and a new methodology and a new parameter were used in this study. The field measurements have shown that there is significant inequality among the deliveries to the various tracts, and further inequality in the distribution within a tract; the scale of inequality is such that, on average. the most fortunate 10 percent of the land receives at least 2.35 times the water received by the least fortunate 10 percent. Deliveries are also not uniform in time, and fluctuate widely. To cope with the sources of inequality, there seems to need to issue from the tank sluices well over twice the theoretical needs, just to counteract the effects of unequal distribution. Such a policy would over-supply most of the land, and the excess supply to these fields would not be productive; the wastage doe to this problem is likely to be more than the losses due to seepage.

Management proposal. The main proposal for introducing new methods of management in the system is the suggestion of an on-site micro-computer at the Irrigation Engineer's office. It would enable him to make better-infornled decisions about water distribution, which should lead to reduction of inequalities, better response to rainfall, and reduction of total water demand. In the longer run, this should mean that Kaudulla would make less demand upon the supplies of the Mahaweli system, with no loss of productivity at Kaudulla. It should be possible, with better control, to improve yields with a reduced total water supply.

To use a micro computer management information systems to its full potential, Abernethy (1985) says there are three main physical requirements in the field: water measuring facilities (preferably automatic); head-regulating structures; and better communications. Development and evaluation of such a system is expected to be a three-year program.

The second report (Abernethy **and** Weller 1987) presents and analyzes field data collected in the two-year period April 1983 - March 1985 in three small irrigated paddy-growing areas of 50 ha (120 acre) each within Kaudulla irrigation system. The data for the study were collected on site by Irrigation Department field staff. The objective of the work was to investigate the questions of adequacy, uniformity and timeliness of water supply within some land **units** of 50 ha each, within selected tracts.

No flow measuring arrangements existed in any of the channels. The measuring system was based on water level observations at existing drop structures which were calibrated. These flow measuring structures divide the study areas into 19 sub-sections, each of which receives all its canal water deliveries from outlets that lie between a certain pair of measuring points. The average area in a sub-section is **19.2** acre (7.76 ha). Water levels were recorded at each of the measuring points once daily.

The main conclusions drawn from analyzing the field data include:

Adequacy. **All** three areas, and all 19 sub-sections, in all seasons of measurement, received sufficient water for the needs of a rice crop. **In** 95 percent of the data, the water supplies were significantly in excess of need, and must have led to significant wastage of water. The parts of the system that receive less canal water make better use of the available rain, but the proportion of rainfall that was effective for crop growth was generally quite small, and on average it was less than **20** percent.

Inequity. Inequity of canal water distribution within each of the study areas was worse than in the Kaudulla main system.' When the contribution of retained rainfall is included, the inequity is reduced. Inequity is not a great social problem (since the supplies of water are generally adequate) but it implies waste of water where people receive more than they require. It is part of the reason why in some seasons, the volume of water in the tank after the maha season is not sufficient for a full yala cultivation.

Timing. The timing of water deliveries was erratic. This may be a reason why farmers wish to keep high levels of water in the fields, and are therefore often unable to retain rainfall when it arrives. **In** the study areas, it appeared that in the great majority of cases farmers were keeping average standing water depths in excess of **2** inches (50 mm) for nearly all of the season, and in excess **of 4** inches (100mm) for a substantial part.

Inginimitiya Project

Franks and Harding (1987) describe the results of research into water management practices during the commissioning of the Inginimitiya irrigation project in central Sri Lanka. This is a **2,500** ha newly-constructed rice irrigation settlement scheme. It is situated on the banks of the river Mi-Oya and is supplied by two main canals, one on each bank of the river, off-taking from a storage reservoir. The research was designed to provide practical answers to the following questions:

* What, in terms of water use, can be expected to happen during the early stages of project commissioning?
* What management practices should be adopted, in the light of this?
* What effect will this have on long-term scheme viability?

The research was carried out over seasons **2-4** of project operation; some additional data were available from project sources for season 1. Water use was assessed by daily measurement of discharges at the head of the right bank main canal and at various distributary and field channels down the system.

The analysis of water **use** was based on two parameters, the total depth of water applied per season (often referred **to** as the "seasonal duty") and the maximum weekly demand. **A** measure of performance, known as the "performance ratio" was defined in two ways:

$$\frac{\text{Seasonal duty at full development}}{\text{Seasonal duty during commissioning}}$$

$$\frac{\text{Peak weekly demand at full development}}{\text{Peak weekly demand during commissioning}}$$

The results suggest that an individual field channel command area uses twice an much water in the first season of irrigation as forecast for full development. hut that it thereafter uses only the expected amount. This makes it possible to define a target phasing of land during commissioning. It was also concluded in the analysis that the phased introduction of newly irrigated land would have had no significant effect on the assessment at the feasibility stage of the project's viability.

Three important guidelines for managers involved uith commissioning similar new schemes are suggested: 1) plan to irrigate 50 *percent of the land* in the *first season;* 2) *institute the design water allocation* procedures as soon as possible; and 3) after the first season of irrigation, farmers should be free to cultivate their full area. or as much of their land as they feel able to. with their knowledge of the likely pattern of water supplies.

Lessons Learned

The important findings of the studies reviewed here have a number of common elements. These include:

1. Monitoring and evaluation of irrigation system performance is difficult and very expensive in terms of resources. i.e. money, time and effort.

2. Maha season water deliveries are generally high and rainfall is not effectively used. Productivity per unit of water is low. Water saved in maha can be used in yala when uater is really scarce.

3. Generally, water deliveries are not timely. nut predictable. and not reliable. Water distribution is inequitable at the main system level as well as at the farm level. The important causal factors for this state of affairs are related *both* to the *complexity of the system* and physical constraints. and the constraints related to resources, institutions, and behavior of the operators and the water users.

4. Main canals are long and do not have adequate controls and cross regulators. In cases where the canals are single-banked and pass through intermediate minor tanks. water conveyance along the system takes more time than in the case of double banked canals. Conveyance losses are high in some canal reaches.

5. There are instances where farmers have generally been cooperative and tried to follow the designed operation schedules once they developed confidence in the system. However, there are practical difficulties in implementing operational plans a! the farm level. Cultivation calendar\ are not followed as agreed to. leading to wastage of water. Farmers have no incentives to save water. Sanctions to deal with violators of discipline are not enforced and are therefore not effective. Many unauthorized outlets from distributaries and the presence of many encroachers and lease-holders makes it difficult to get organized or disciplined behavior from farmer\.

6. Irrigation water requirements are higher than design values in the earl! stages of commissioning of a project.

7. *Rotational water distribution introduced in* systems designed for continuous distribution can lead to inadequacies in system capacities.

8. Water measurement devices like weirs are not liked by farmers and are frequently damaged.

9. Inadequate funds for maintenance and lack of motivation for system operating personnel are quite pervasive and lead to poor system performance.

10. The reasons for low productivity at the farm level are very complex and result from interactions of physical, agronomic, economic, social and institutional factors.

Research Questions

1. What methods, and conceptual basis for these methods, could he developed for assessing the performance of an irrigation system in a holistic sense without having to collect a lot of data?

2. What operational and institutional assumptions are made in designing turnouts and field channels? Are they realistic? What is the impact of the design of field channels and turnouts on the operation of distributary canals.

3. What alternative water distribution methods and practices that are easy to implement and that can lead to improved water delivery at the tertiary level could be introduced?

4. What irrigation water distribution methods can farmers use that provide flexibility in operations when there is a mix of rice and diversified crops under the same turnout?

5. What are the sources of improvement of the performance of irrigation systems, and how effective would they be? Some examples include:

   a) development of low cost electronic devices for flow measuring,

   b) design of economic and effective flow control and regulating structures which are manageable in a technical as well as institutional sense, and

   c) providing an irrigation management extension service that leads to better interaction between operating personnel and farmers and improved communication methods.

6. What technical, financial and institutional innovations could lead to improved O&M of irrigation systems?

ORGANIZATION AND MANAGEMENT

This section reviews recent research and other literature on irrigation organization and management in Sri Lanka, under four major headings: policy and law, management at the agency level, management at the farmers' level, and other social issues. In each case it endeavors to identify the major work that has been done, the key findings or lessons learned, and the most important research questions and gaps in knowledge.

Policy and Law

Policy and legal issues are not a major focus of this review. This is not to say they are not important -- they are indeed extremely important. Basic research on broad agricultural well as specifically irrigation-oriented policy options could make a very important contribution to future development of irrigated agriculture. However, the discussion here is limited to issues that directly affect progress on strengthening irrigation management institutions, both government and farmers'.

Abeywickrema (1986) provides an up-to-date overview of the evolution and rationale for government policy in regard to participatory management. After explaining the relatively strong governmental role in the development of major irrigation schemes, he notes that in some respects government agencies have "faired poorly" in achieving their objectives. Hence government interest in participatory management of irrigation schemes if this can he shown to he more effective. The result is a "let 100 flowers bloom" approach, that is, encouragement of a variety of institutional experiments, but no commitment to any particular approach.

Alwis (1986) traces the history of legislation in regard to irrigation development and management since colonial times, and points out that legislation by itself cannot bring about farmer participation, supporting an argument presented several years earlier by Uphoff (1982). Nevertheless, laws can provide a broad framework to legitimize and strengthen such organizations; Alwis (1986) therefore recommends amending the current Irrigation Ordinance based on the lessons learned in recent years from efforts to organize farmers. More recently, Merrey and Bulankulame (1987) have suggested that Sri Lanka adopt as a long term goal the turnover of all small and medium sized systems, and the lower distribution portions of large systems, to farmers' organizations. Implementation of such a policy would require enabling legislation to provide the necessary framework.

Sri Lankan policy in regard to the allocation of responsibility for irrigation system management between government and farmers has evolved considerably in the last decade. It would be useful to establish clearly the long and medium term objectives, and then carry out policy research on what the legal options are, what changes might he required in existing law and in the existing mandates of particular government agencies, and what would be the most effective strategy for achieving the objectives. Alternative models for irrigation management, such as irrigation agencies as public utilities, and turning system ownership and management over to farmers' organizations or farmer-owned companies could also he examined. Financing policies are critical at this level as well.

Management at the Agency Level

Since all major irrigation schemes are owned, built, operated and maintained by government agencies in Sri Lanka, one would expect that research to identify the impediments and opportunities to improve their performance would begin with questions about the agencies' operations themselves. However, as is true in other countries, the study of the management agencies and their managerial performance is still rare. It is much easier to study either purely technical questions, or to study "farmers", with the implicit assumption that most problems are found at the level of the farmers. As a result, the behavior and performance of irrigation management agencies has remained a neglected subject, a veritable "black box" about which anyone may speculate hut few understand.

Various studies show the potential for improvement in the performance of irrigated agriculture through management innovations above the farm level (see for example Bottrall 1981, Wade and Chambers 1980). In most cases, such potential is demonstrated through a concerted effort by officials during a crisis period, or by researchers able to invest sufficient resources. However, it is difficult for agencies to sustain such extraordinary efforts over a longer period without implementing changes in the agencies themselves and the resources at their command. The question, then, is how can agencies develop a better capacity for sustained high performance management?

In Sri Lanka, a number of articles have been written suggesting reasons for poor system performance that relate to agencies, or suggesting general approaches to improving agencies' management capacities. For example, in a report evaluating the original Appraisal Report for the Tank Irrigation Modernization Project (TIMP), Ranatunge et al (1981) suggest that the "risk-averse strategy" of the Irrigation Department is a key factor leading to late and unreliable water issues. They suggest the need for a strong comprehensive management strategy, involving cooperation between agriculture and irrigation and retraining of officials including engineers.

Harriss (1977) discusses control and manipulation of the (irrigation) bureaucracy by local elites who thereby obtain a preponderance of the benefits. Chambers (1977) suggests that. on large systems jointly managed by farmers and an agency, an impartial and independent bureaucracy is needed to execute allocation of water among "communities" and for some provision for acting as a court of appeal, including the authority to police and prosecute infringements of the rules. "The key lies in the reform of organization and operation -- in short, in improved management of men" (Chambers 1977:361). Karunanayake (1982) also emphasizes the need for a water-specific system of justice -- water courts. He also calls for a greater emphasis on system management, including regular policing at above-community levels, and a re-orientation of both training and incentives to emphasize O&M.

The major systematic study of a Sri Lankan irrigation agency published to date is the work of Moore (1980a and b, 1982) and based on research on the Irrigation Department nearly 10 years ago. His analysis is from the theoretical perspective of "organizational theory." Broadly, Moore's papers attempt to identify the sociological factors underlying the low productivity of irrigation systems with special reference to the irrigation bureaucracy itself.' The reason for this focus is not that all the causes are within the agency, but that the main effort to improve irrigation management must come from a reformed bureaucracy. Only the bureaucracy, he argues, has the capacity lo intervene and change the other factors external to itself.

He identifies five major factors which discourage work performance (most are not unique to irrigation agencies). These are: patterns of recruitment that impede interaction between public servants and cultivators, patterns of recruitment and rewards that inhibit internal communication in the agency. use of inappropriate indicators of management capability, lack of incentives for good management, and devaluation of management (O&M) as opposed to design and construction. In view of these, he suggests a number of strategies for improving performance (see especially Moore 1980b).

Moore (1982) notes that much of the pressure on established agencies like the Irrigation Department is the result of changing conditions and expectations. In this circumstance. organizations always try to perpetuate themselves either by attempting to defend their original functions and ways of doing things ("natural conservatism"), or by reorganizing and reorienting themselves. The Irrigation Department had in fact been responding by making changes, but slowly, since it seemed to Moore at that time to have a limited capability to change significantly.

Murray-Rust (1983) provides a detailed study of the management of the Gal Oya system at the main system level, from a combined engineering and institutional (socio-technical) perspective. Building on Moore to some degree, he provides further details on the factors affecting the Irrigation Department's ability to respond to changing demands in the short- and long-term. For example, he finds that decisions made before the irrigation season, policies and pressure from outside the scheme, and the structure of the bureaucracy itself seem to have more effect on operations than changing water conditions within the scheme during the season. If changes in main system operations are contemplated, the consequences of such changes and the managerial and technical limitations of the department ring study of the operation of a major irrigation scheme.

More recent work primarily related to the Water Management Project in Gal Oya suggests that in fact the Irrigation Department has changed more than Moore (and possibly Murray-Rust) might have expected. Uphoff (1985a and b,

1987) notes that a key objective of the farmers' organization program was in fact "bureaucratic reorientation", a change in the attitude, orientation, and performance of the Department. He lists the improvement in officials' attitudes and performance as one of the three major accomplishments of the work in Gal Oya (Uphoff 1987). Merrey and Murray-Rust (1987), based on interviews with key department officials involved in the Gal Oya rehabilitation project, plus the evaluations done by ARTI and independent consultants, confirm this perspective. They suggest that the Irrigation Department is presently in a transitional stage and that the present informal policies regarding a greater management- and farmer-orientation should be made explicit and clear, and should include specific incentives and training programs to make them more effective.

Before the beginning of each cultivation season, the law requires that a cultivation (*kanna*) meeting be held. All cultivators are invited to attend this meeting, which is chaired by the government agent or his designee, and attended by representatives of all the irrigation and agriculture-related departments. Murray-Rust and Moore (1983) analyze the cultivation meetings they independently observed at Gal Oya and Kaudulla. They show the cultivation meeting format is inappropriate and ineffective on large irrigation schemes, especially as a decision-making mechanism. They suggest a number of alternatives, including replacing such mass meetings with committees of elected representatives (i.e. project committees) and concentrating attention on delivering water to distributary heads where farmers' organizations could take over, rather than facing the complexities of trying to deliver promised amounts of water reliably to field channels. One "positive function" mentioned is embarrassment of officials as a check on poor job performance, but this would not seem a very effective mechanism for performance monitoring.

At present, research on agency-level management issues is shifting to a new approach! Whereas the work of Moore, for example, derives from sociological theory on organizations, tends to emphasize structural issues, and tends to be "external" to the agency in its perspective, recent research has attempted to examine the internal management processes based on methods and insights derived from modern management approaches. This work is done with the close collaborcy officials – indeed it cannot be done with-out this support. The role of the researcher in such work is closer to a management consultant than to a traditional researcher. In principle, this work can lead to identifying key impediments to an agency's ability to achieve its objectives, and to suggested means to improve the performance of agencies and their employees. Two examples of such recent work, not yet published, are Raby (1988) on the Irrigation Management Division (IMD), and Raby and Merrey (1988) on MEA's management system in System H.

An evaluation of the effectiveness of the INMAS program within IMD is presently underway; and the studies on financing O&M discussed in another section of this paper are also relevant to defining issues and developing testable solutions in agency-level management. Evaluations, and "conceptual" studies from various theoretical perspectives (such as organizational theory, public choice theory) are valuable in defining larger policy and strategic issues, and suggesting broad solutions. "Internal" management studies are useful to identify and test ways to improve the effectiveness of organizations to achieve their objectives.

The major research questions emerging from this review are: First, how can the effectiveness and performance of irrigation management agencies be improved? The objective would be to examine the present management systems, for example performance monitoring and control of personnel; recruitment, training, and incentives policies; communications (management information systems) both within the agency and between agency officials and clients; decision-making processes; and organizational goals, mission, and values (culture). The methods would include participant observation, interviewing, examination of files, etc. in the fiat stage, followed by a stage of collaborating with agency officials to develop, test, and evaluate alternative management procedures and methodologies, including those which have been used by other public and private organizations to change themselves.

More detailed questions would emerge from the specific context to be studied. For example, the IMD has the responsibility for both coordination of agencies providing inputs for irrigated agriculture at the project level, and development of farmers' organizations. This is to be achieved by a "Project Manager", sometimes but not always assisted by an institutional development officer and/or institutional organizers. Are the expectations regarding the project manager reasonable? Does the IMD system of performance monitoring, incentives and rewards, Colombo-field communications, etc. tend to encourage or discourage the performance expected? What kind of a management information system would be most appropriate for IMD? Similar detailed questions could be developed for other organizations.

Second, training issues need far more investigation. IIMI (1987) carried out a survey of present training capacities and likely future needs, and made certain recommendations for more effective use of existing training facilities. But many questions remain unanswered. What is the impact of present training programs on actual behavior and performance of individuals, and agencies? What are the skills most needed by existing personnel? What should be the balance between training in specific techniques and technologies, e.g. water measurement, and training intended to support institutional strengthening and management improvement?

Management at the Fanners' Level

This section deals with both farmers' organizations, and the interface between fanners and irrigation agencies. Sri Lanka is well-known for a number of interesting experiments with promoting farmers' organizations, and there is a lot of literature on the subject, though not all of it is useful. Several authors have noted that the absence of effective local level organizations and leadership is a major factor explaining disappointing irrigation system performance, and impeding improvements (for example Karunanayake 1980 and 1982, Moore 1980a, Alwis et al 1983a and 1983b, Chambers 1977, Gunesekere 1981). Some authors trace this absense of effective local organizations to the increasing intrusiveness of government in recent times which has under-mined the traditional system and engendered a dependency on outside forces, and to the changing policies and legal arrangements since Independence (e.g. Gunesekere 1981, Karunanayake 1980). Others suggest that the official control of settlement schemes has discouraged the development of local organizations (Chambers 1978, Lundquist 1986).

In his review of water management problems on large schemes, Moore (1980a) expresses strong reservations about the likely usefulness of promoting farmers' organizations as a means to improving irrigation system performance. He suggests that they: 1) will be unable to deal with local conflicts; 2) have a dismal record on sustainability; 3) are premised on a false image of the social composition of settlement schemes; 4) and would detract from the more crucial need, reform of the bureaucracy. Put another way, the concern expressed is the trade-offs between elected leaders who face limitations in what they can accomplish versus an impartial external authority able to impose discipline. Nevertheless; since the late 1970s, there have been a number of experiments with farmers' organizations that have generated considerable interest and been quite influential with Sri Lankan policy makers.

An interesting pioneering effort that does not appear to have led to any permanent impact is the one at Thannimurripu, Vavuniya District, documented by Ellman and Ratnaweera (1973). An administrative board consisting of officials and elected farmer leaders was established to deal with system problems when the line agencies found it difficult themselves to solve them. Based on a rather short study 2.5 years after it was started, the study concludes the effort to date was a "qualified success."

There are several more recent and contemporaneous experiments that have had impacts beyond the system on which they were done. These are the Mahaweli Turnout Groups, the committees formed at Minipe, the Kimhulwana case, and the farmers' organization program as part of the rehabilitation project in Gal Oya. There have been other efforts, some discussed in papers in IIMI (1986), but these are the major influential cases.

Mahaweli turnout groups. The turnout group program was initiated in parts of System H in 1979. A concentrated effort was made to develop farmers' groups below the turnout to carry out irrigation tasks and to facilitate agricultural extension and training. These efforts are described by officials who had been involved in the program (see Karunatilake 1986, Jayawardene 1986). According to these authors the program is being implemented in the new Mahaweli systems (B, C, etc) as well. It is important to note that the original concept was limited to the turnout only; Karunatilake (1986) in fact expresses reservations about federating them at the distributary level. However, in System H today there are D channel representatives, though their functions are not clearly defined.

Several authors have raised questions about the effectiveness of the System H turnout groups (see Karunanayake 1980; Lundquist 1986; Bulankulame 1986). Lundquist claims that despite the high hopes of the officials, after several years experience with turnout group leaders, a survey of farmers showed "an overwhelmingly negative attitude toward them." Lundquist notes that even though the leaders are supposed to be elected by and from farmers, in fact they tend to be from more elite groups, and in many instances are nominated by the officials and are often extensions of the bureaucracy, doing things officials should do (Karunatilake, 1986, also mentions this problem). Bulankulame (198616) found that farmers are uncertain about the role of their representative, and often bypass him; further, members often do not see themselves as a group, in part because of residential dispersion.

The Kimbulwana case. Kimbulwana is a medium sized scheme in Kurunegala District which was rehabilitated in the late 1970s/early 1980s. The Irrigation Department's Technical Assistant (TA) in charge of the project spent some years developing a highly-disciplined approach to system management with the participation of the farmers. A video film has been made documenting the experience; an evaluation was written several years ago (Weeramunda 1985), and more recently with IIMI support the TA has documented his approach from his own perspective (Gunadasa 1988). Gunadasa's approach cannot be characterized as "participatory" in the usual sense; rather, he imposed a structure for consultation and decision-making and was able to impose the kind of discipline in water management that surveys often show farmers would prefer.

It has come to be seen as a success story since as a result of these efforts, irrigation efficiency apparently improved, productivity improved, fanners have been able to get an extra crop occasionally, and the system is said to be well-maintained. Weeramunda (1985) lists five major characteristics: it is disciplinarian in structure and character, it combines discipline with elements of participation, it is an efficient water management system, fanners and officials both view it as a success, it is based on "bureaucratic leadership" in which a particularly dedicated official won the farmers' compliance, and its long term viability (sustainability) is doubtful.

The last point is important; Weeramunda's (1985) evaluation suggests that the farmers' attitude is one of compliance and complaisance, younger and more critical people have been excluded, and there is a failure to develop local leadership independent of the TA. Gunadasa of course does not agree with this evaluation; it is difficult to evaluate the sustainability of the effort until Gunadasa leaves. A study to examine what lessons there might be at Kimbulwana that are transferable is needed: it is clear that farmers often prefer an impartial external authority to impose discipline, but could this be done effectively and fairly on a wide scale by the present government institutions?

The Minipe experience. The case of the effort to organize farmers for water management at Minipe Scheme illustrates the problem of sustainability after the source of inspiration departs. The water management project at Minipe, initiated by the then Deputy Director of Irrigation for Kandy, N.G.R. de Silva, attempted to set up a committee system to enable farmer participation in system management. This has been described by de Silva (1981, 1985) and evaluated by Peiris (1987) after de Silva bad left. Peiris finds that while there had been some positive impact of the project, this was less than had been hoped. He attributes the lack of sustainability of the organizations to several factors, including problems of getting line departments to cooperate, problems in implementing project committee decisions, and problems arising from the agrarian social structure and the physical system's poor condition. Peiris expresses skepticism about the extent to which farmers *can* "participate" in matters that are part of the administrative domain.

The Minipe experience is of particular interest for several reasons. It was the pioneering effort to use "catalysts" in initiating the transformation process among farmers -- in this case young people fielded by the National Heritage Programme in a pilot area during the first year. Informal group representatives were elected from among the farmers to assist in water management, and coordinating committees were established. In a later stage of the project, a committee system with formal farmer representation was established throughout the system, but without the benefit of the catalysts. Farmers' representatives were elected by secret ballot under the Agrarian Services Act, and there were six Sub-Project Committees and one Project Committee on which both field officers and farmers sat.

The Gal Oya project. From 1978-85, the Irrigation Department rehabilitated the Left Bank of Gal Oya, with funding and other assist USAID. An integral component of the project was an effort to organize farmers' groups which was implemented by ARTI with some assistance from Cornell University. This component of the project in particular has attracted wide national and international interest, and has had considerable impact on government policy and on donor policy as well. The team which did the final evaluation of the whole project termed this aspect of the program a success, but complained about the volume of reports on the project (ISTI 1985).

The most useful discussions of this effort in our view are contained in the following: Wijayaratne (1985); Uphoff (1985a and b, 1986, 1987); Perera (1986); and Merrey and Murray-Rust (1987). The papers by Wijayaratne and Uphoff discuss the program from the point of view of the two key people who set up and guided it; Uphoff (1986) puts the effort into a broad comparative perspective; Perera's (1986) paper provides a useful overview but from a more critical perspective; while Merrey and Murray-Rust (1987) look at the impact of the program on the Irrigation Department from the perspective of the key Department participants in the project.

An important feature of the program was the use of "catalysts" called Institutional Organizers (IOs) to work with farmers in organizing groups. The IOs were all graduates in social or agricultural sciences who were trained in various aspects of water management, group dynamics, and organizational methods. They resided in the communities and developed close personal relationships and an intimate knowledge of the communities. This enabled them to work effectively with farmers to assist them in forming field channel (FC) groups, and later larger organizations based on field channel representatives. The FC groups were expected to carry out FC maintenance, organize water sharing programs where needed, and work closely with the Irrigation Department engineers in the design and reconstruction of the FCs. One or more FC representatives was to be chosen by the farmers to be a spokesperson for them at distributary committees and Area Councils.

According to the official evaluation, by late 1985,350 FC organizations had been formed over an area of 10,250 ha; above these were 27 D channel organizations, 6 area councils, and a project committee (ISTI: 1985). The evaluators felt the 420 farmers' representatives on the whole were responsive to farmers' needs and 60-80 percent of the farmers in the organized area were participating directly or indirectly in the FC organizations. According to a survey carried out by ARTI, both farmers and Irrigation Department engineers expressed a high degree of satisfaction with the organizations, and particularly with their representatives (see ARTI and Cornell 1986; Perera 1986).

Unfortunately the prevailing conditions in Sri Lanka have prevented any recent evaluations of the Gal Oya farmers' organizations. But based on interviews with two key Irrigation Department officials in mid-1987, Merrey and Murray-Rust (1987) found that the organizations had apparently endured even after the end of the project; and the improvement in both *discipline* among farmers and at the agency level and *communication* between farmers and agency, enabling more effective operation of the system, remained the key benefits in the eyes of these officials.

Comparison of different experiments: lessons and research questions. It is interesting to compare and contrast the experience at Gal Oya with the experience reported in other systems in Sri Lanka. Like the Mahaweli Turnout Groups program, this was an officially sponsored effort on a particularly large irrigation scheme. However, the Mahaweli program was implemented by a bureaucracy that is relatively dense and has multiple (integrated) responsibilities at the field level. It had a more limited objective -- organizing at the turnout only -- and limited expectations --the groups were primarily conceived as a mechanism for the agency to train farmers (one way communication). The Unit Managers, part of the bureaucracy, organized the groups. There was little emphasis on the *process* of organization and learning lessons from the experience as the process unfolded.

At Gal Oya, there was relatively little coordination among line departments, and the Irrigation Department had a narrow range of responsibilities. Its staff was comparatively less dense per unit area or per farmer. The program was implemented by a research organization that could work in a flexible and decentralized manner. The objective was more ambitious than in Mahaweli System H -- farmers were to be actively involved in the rehabilitation effort, including decision-making and contributing resources, and as the program evolved, in system management at various levels, not just the FCs. The IOs were on two year contracts with ARTI; they were not part of the bureaucracy. There was a great emphasis on "getting the process right" -- the title and theme of Uphoff's (1986) book -- and learning from the process.

The effort at Minipe used catalysts, apparently successfully, in the beginning, but this did not continue. The farmers did respond to the opportunity to participate in improving and managing the system. However, the program was not sustained because the effort required to overcome the impediments in both the agrarian social and economic structure and the bureaucracy itself were not sustained. The Kimbulwana experiment was "catalyzed" by one dedicated person. The notable contribution here is the acceptance by farmers of a high degree of discipline imposed from outside, plus a considerable degree of collective responsibility for system maintenance. The question of sustainability is a serious but unanswerable one at this stage.

These experiments suggest a number of key lessons, but raise further issues requiring applied research. The lessons include:

1. Farmers will respond to opportunities to take greater responsibility for system O&M in cooperation with government officials.

2. The use of specially trained catalysts, deployed in communities with a mandate to spend a couple of years working with farmers is an effective method for organizing responsible and useful farmers' organizations.

3. The presence of such legitimate and effective farmer organizations leads to improved cooperation among farmers, and improved cooperation and communication between farmers and agency officials. This in turn makes the agencies' jobs easier, and increases the incentives of officials to be responsive. These improvements in turn can lead to improved system performance on a sustained basis.

4. The development of farmers' groups and changes in irrigation management agencies are mutually supportive; in the long run, both must occur, and changes in one have a strong impact on the other.

Numerous research issues also arise from these experiences, including:

1. What has been the level of sustainability of the farmers' organizations formed at Gal Oya, Kimbulwana, and Mahaweli System H, and what are the reasons?

2. What modifications could be made in the IO program to improve the efficiency of implementation over a larger scale? This would suggest some experimentation with different types of IOs (e.g non-graduates, persons from the community) and different recruitment methods (e.g. contracts, use of existing staff, use of NGOs).

3. What modifications from the Gal Oya model would be required for success in systems where conditions are different from Gal Oya [e.g. different ethnic groups, already existing organizations requiring strengthening, different management agency such as Mahaweli Economic Agency (MEA)] or where the project objectives are different (e.g. not a rehabilitation project, shifting a system from rice to mixed cropping, improving efficiency on a water short system, improving maintenance).

4. Are there alternative methods of organizing farmers' groups that would he effective and perhaps less costly financially and in terms of management intensity in achieving program objectives? For example, can IMD Project Managers, or Unit Managers in Mahaweli systems, implement such a program effectively on their own? If so, under what conditions?

5. What is the most appropriate division of responsibilities and overall relationship between the existing agencies and farmers' groups in the short run (say five years)? What would be the most appropriate mixture of roles, and types of organizations to be developed in the long run? For example, can/should distributary groups take over both operational and maintenance responsibilities on their distributary? Would an organizational framework in which there is a contractual relationship between a farmers' group and an irrigation service agency be more appropriate in the long run? What role can farmers' representatives play in overall policy and decision making on large irrigation systems? What factors inhibit and what factors encourage such participation?

Other Social Issues

There are a number of other social issues that are not directly irrigation management issues, but that relate very closely, either in terms of their impact on efforts to improve irrigation system performance, or in terms of the potential broader impact of improved irrigation performance. These issues include (hut are not limited to) the following:

1. concentration of other productive factors necessary for agricultural production, such as land, access to credit and inputs, and farm power;

2. land tenure issues and settlement policies (residence dispersion for example) and their relationship to irrigation management;

3. employment generation, especially as it relates to second generation settlers; and

4. the relationship between family size and structure, including particularly women's roles, and irrigated agriculture.

Concentration of land control has been reported on settlement schemes, (Abeysekera 1986) but not well-documented. Concentration of farm power has been documented (see Abeyratne and Farrington 1986). The farm power study carried out on three major schemes in 1979-80 documented the interactions between unequal access to water of head and tail farmers and unequal access to farm power. Since such interactions can lead to a situation of increasing inequality, which in turn could make efforts to use management and organizational interventions to equalize water deliveries problematical, further research is required. A high degree of social inequality will make development of effective farmers' organizations difficult.

There are a lot of issues related to trends in land tenure and the relationship between settlement policies and practices, and irrigation management. Studies of settlement schemes consistently find very high levels of leasing, mortgaging, tenancy, fragmentation, and outright but non-legal sales (see Bulankulame 1986, Ekanayake and Groenfeldt 1987, Abeysekera 1986, and other references in Stanbury 1988). These have very important impacts on the effectiveness of farmers' organizations; for example, should non-allottees be excluded? If they are, and if more than half the cultivators on a channel are non-allottees, how can such an organization be effective? A recent literature review (Stanbury 1988) has highlighted land tenure and other settlement-related issues requiring further study in terms of their impact on irrigation management.

The problems of the second and subsequent generations of settlers in terms of their limited access to land and employment, and the impact of this limited access on the resource base in Gal Oya, was studied by Abeyratne (1982). She documents the adaptive strategies of such families, given their limited opportunities, and notes that under- and un-employment, poverty, and lack of access to resources, the very conditions settlers came to the Dry Zone to escape, are repeated in the next generation. This major study on this subject confirms the common perception. It relates more broadly to the question of the role and potential impact of irrigation management in trying to reduce poverty, especially among those with limited access to irrigation resources. Research on these problems goes beyond irrigation management, but the issues are crucial to the long term viability of irrigation schemes.

Finally, another under-studied topic is the relationship between family structure and irrigated agriculture, and in particular, the impact on, and role of, women. The study by D. de Silva (1982) provides an overview of women's adaptation in a Mahaweli scheme, while Kilkelly's (1986) survey in Polonnaruwa provides interesting data but little analysis. Although studies of women in development have very rightly and rather belatedly become more common, no one has yet identified specific research problems related to irrigation management in Sri Lanka.

REHABILITATION

Selected papers and reports on the major rehabilitation experiences in Sri Lanka in the last decade are reviewed. The cases include the Tank Irrigation Modernization Project in the northern part of the country and the Gal Oya (left bank) Water Management Project in the east of the country. There is a considerable body of written material on the subject. According to the final evaluation report on the Gal Oya Project (ISTI 1985), a bibliography on that project prepared by ARTI lists 159 separate studies and reports. This review attempts to identify the principal results of the rehabilitation experiences to help formulate research questions for studying the rehabilitation process in other projects.

Tank Irrigation Modernization Project (TIMP)

TIMP was the first major rehabilitation program in Sri Lanka and introduced several innovations in agriculture and irrigation, together with supporting institutional arrangements. Abeysekera (1986) documents the limited impact of the

TIMP on one system, Mahavilachchiya, and attempts to explain why this is so. He discusses the social, economic and demographic background of Mahavilachchiya, showing that high population growth in the context of a limited land base and highly uncertain water supply have resulted in very slow increases in production and income, increasing economic stratification as shown by the increases in landlessness, mortgaging of land, and indebtedness. Major changes in the irrigation system and agricultural production system were attempted under TIMP, with unsatisfactory results. The fanners are said to have rejected the agricultural innovations.

Abeysekera does an economic analysis of these and other possible innovations, including dry sowing, advancing the sowing time, using short season varieties of rice, crop diversification, and saving water from maha to enable a yala crop. He finds that in all *cases*, under present conditions, the highest long term income comes from the current conventional practice of planting a long season variety of paddy late in maha.

He suggests a number of implications for Mahavilachchiya, including the need for long term government policy changes to promote economic growth, the importance of involving farmers in irrigation management, the need for agricultural practices more compatible with farmers' interests and resources, and the need for institutional support for marketing aad credit. In future rehabilitation projects he suggests looking beyond purely engineering solutions and focusing on building farmers' organizations, providing more adaptable agricultural technologies; and incorporating fanners' knowledge and experience in designing rehabilitation projects.

The report by Ranatunge, Farrington, and Abeysekera (1981) attempts to draw together some of the broad themes and lessons from the baseline studies of the five tanks rehabilitated under the TIMP in 1977-83. It re-examines the original World Bank Appraisal Report regarding the problems and the proposed solutions, and points out the inadequacy of the Appraisal on several issues. It suggests, based on the data from the baseline studies and other sources, that the issues surrounding early tilling and sowing were not identified clearly, which led to a misdirection of investments toward Cwheel tractors and, more important, to ignoring the management support system that would be required to implement early tilling and sowing.

On crop diversification, the Appraisal inadequately identified the roots of the problem. Ranatunge et al. (1981) believe this will require a long term multi-pronged effort. Finally, on the tail end problem, the report suggests that there is considerable scope for improving crop intensity and yields (at the tail), but other problems such as poor roads are as important as water. The report claims the monitoring of TIMP's impact was inadequate.

The single main theme underlying the staggered mudland tillage system is identified as *confidence*, and therefore also motivation. It attributes much of this problem to the highly risk-averse strategy of the Irrigation Department, which leads to late and unreliable issues of water in early maha for example. It suggests the need for a strong, comprehensive management strategy, that would involve cooperation of agriculture and irrigation, intensive field efforts, re-training of officials.including engineers, and assistance from political authorities. The organizational efforts required are said to have been neglected in the appraisal.

Murray-Rust and Rao (1987a and b) also examine the TIMP case. The experience and lessons learned in TIMP have influenced the planning and design of the Major Irrigation Rehabilitation Project (MIRP) which is currently being implemented in some of the seven tanks included in this project. They emphasize the important innovations attempted in TIMP, the experience gained, and the modifications introduced in MIRP, partly as a result of the experience with TIMP.

TIMP had a number of substantial objectives aimed at water conservation in both wet and dry seasons:

1. increasing cropping intensity through crop diversification in the dry season;

2. early land preparation for wet season rice, based on mechanization and dry seeding, to use early rainfall and conserve tank water for the following dry season;

3. use of short duration rice varieties in the wet season;

4. improved equity of water distribution through introduction of strict rotational delivery schedules; and

5. redesign of the conveyance system, lining distributary and field channels, introduction of water measurement capability within the system, and construction of cross regulators in main channels.

Agricultural innovations. Dry tillage, dry seeding, and short duration varieties constituted a package requiring mechanization, timely water supplies, and varieties that ripen in 3.0-3.5 months. Tractors were made available, but water conditions were never such that farmers were induced to change from traditional practices. Dry sowing is now rare. Farmers seem to prefer to ensure one good wet season rice crop, use irrigation water for land preparation and crop growth, and plant 4.0-4.5 month rice varieties.

Uncertainty over water and lack of marketing arrangements were major constraints to crop diversification and adoption of non-rice crops. Water management was difficult since it had to be adapted to two markedly different soils under a turnout.

In MIRP, mechanization for dry tillage is given up, crop diversification is limited, and the package of dry tillage, dry seeding and short duration varieties are not insisted on, though still recommended.

Irrigation innovations. Large scale adoption of parallel, lined rectangular one cusec (28.3 liters per second) channels serving head, middle and tail end areas separately and independently was a major innovation attempted. When the agricultural innovations were not adopted and land preparation for wet sowing of rice brought peak water demands, the one cusec channels proved unsatisfactory. Therefore, in MIRP, the channels are designed to carry up to two cusecs if all freeboard is used. Lining is to be done only where needed and channels will be earthen and trapezoidal in cross-section.

The original design in TIMP limited irrigation deliveries to 12 hours per day, so that no farmers would have to irrigate at night. Rotational schedules were prepared to achieve this objective but it proved impossible to operate the systems in daylight hours only. Rotations were later changed to 24 hour irrigation for a set number of hours per week. The rotational schedule was modified for MIRP by rescheduling discharges to permit all gate operations to be in daylight hours.

The installation of cross-regulators has been a major benefit to water on control in the main channels of the systems. Cross regulation is being provided in MIRP and several other systems at the present time.

TIMP relied very heavily on weir boxes for measurement at distributary and field channel levels. They were perceived by farmers as restricting flows and were widely damaged. MIRP is moving towards installing broad crested weirs, which, although more expensive, are more durable.

Institutional innovations. The transfer of design activities in TIMP from Colombo to a town nearer to the project is the first case of major devolution of design in Sri Lanka, and has been adopted in Gal Oya and MIRP.

The establishment of Tank Committees under TIMP was the first major effort in Sri Lanka to involve farmers formally in managing major irrigation systems. The tank committee structure has evolved into the project manager system of INMAS, the national effort to improve water management through the IMD. This system has also been adopted for all MIRP tanks.

TIMP had no plans to organize farmers. *Vel Vidanes* were used to undertake several water management tasks, including implementation of the rotational schedules, representation of the farmers at the tank committee, and liaison with government officers. It was not satisfactory. Later, efforts were made to organize field channel groups with contact farmers in a system parallel to the contact farmer for the training and visit (T&V) system. These efforts were largely introduced after all design work had been completed.

In MIRP, farmer organization is **a** specific objective of the early phase of the project. Institutional organizers (10s) whose task is to organize farmers into field and distributary channel groups have been hired. In MIRP, there has already been a substantive effort to involve farmers in planning and redesign. The different approach to institutional arrangements in MIRP can only partly be attributed to the experiences of TIMP. There have also been inputs from the Gal Oya experience.

TIMP has contributed significantly to improved understanding of the requirements of rehabilitation projects in Sri Lanka. Many lessons learned have been incorporated into planning and implementation of some subsequent rehabilitation projects like MIRP.

Gal Oya Water Management Project

Five reports and papers representing the views of a mid-term evaluation review team, the contractor for implementation of rehabilitation, researchers, and the final evaluation review team are chosen as a basis for reviewing the Gal Oya experiedce.

A study of the Gal Oya Water Management Project was conducted by a Review team of five members (Keller et al. **1982)** at the request of USAID/Sri Lanka. It was intended to serve as a project review document and includes the team's conclusions and recommendations with supporting background statements. The team identified and pinpointed the constraints which slowed the development of the project and reduced its effectiveness and then developed a set of recommendations for overcoming them.

The concept of *pragmatic rehabilitation* was the main outcome of the review. Instead of using the "textbook approach" to specifying rehabilitation requirements, a more relaxed design approach was recommended and utilized. This approach is to set up standards and criteria in order to do the minimum work necessary to get the desired results in terms of canal safety, stability and carrying capacity. This approach reduces surveying, design and construction costs considerably.

The team also emphasized institutional development and the importance of socioeconomic research and water users' associations. This was a fundamental component of the Gal Oya water management program. Neither the rehabilitation of the water storage and delivery system nor the proposed new rational and comparatively stringent O&M measures can ever achieve their purpose unless accompanied by institutional improvements. Assistance is needed to guide and enforce the recommended management measures and to gain the enthusiastic participation of the ultimate users of the project, the farmers. The team endorsed the consultant's **(PRC)** view that if the Irrigation Department was unwilling to accept the responsibility for integrated water management, then perhaps efforts should be made either to find another agency that would accept this responsibility, or create a new agency.

The report contains many recommendations which led to a redirection of the rehabilitation effort of the Gal Oya project and extension of the project life by about 21 months.

PRC Engineering Consultants International (1985) was the contractor for the Gal Oya Water Management Project with responsibility primarily for planning, modernization/rehabilitation, O&M, and training. The final report prepared by the contractor provides an account of the activities under the project, the project outputs, the problems encountered, and the findings that could be useful for future rehabilitation projects.

The findings cover a wide range of issues. The following are the points the contractor believed are most important for modernization and/or rehabilitation, and project O&M (PRC 1985):

1. Inputs from water users' associations (WUA) are not necessary for the rehabilitation of conveyance systems but would be advantageous. The exception is that the farmers' input is required in the preparation of the general management and work plan. The rehabilitation of a field channel must have farmers' participation, with or without a WUA.

2. The general O&M procedures that will be implemented following rehabilitation should be determmed as part of the general management and work plan. Specific requirements of the operations plan which will affect water control must be included in the design criteria.

3. Training of the project's O&M staff should be implemented as early as possible.

4. The training of non-Imgation Department personnel, particularly local officials and other influential individuals in the community will greatly help the acceptance of water management as a needed means of helping the farmers. It should have a long term effect in maintaining the WUAs as viable organizations and may assist in their federation and the formation of an advisory committee to assist the project manager in setting policy.

This is a useful and informative report presenting the contractor's overview of the project and the problems encountered.

In a comprehensive case study, Wijayaratna (1987) analyzes the rehabilitation effort and experience of the Gal Oya Left Bank System. The paper highlights the innovative and successful approaches used in various phases and activities of the project. It also examines the constraints encountered and deficiencies observed in all stages of the project. This review draws upon these aspects as they have lessons applicable to future rehabilitation endeavors.

The innovative elements identified are the following:

1. The pragmatic approach to design and construction was considered successful in practice. The basic concept of the pragmatic approach was to "...conduct a physical inspection of the system and to determine what was needed to be done to ensure hydraulic efficiency and to stabilize the canal banks. This approach had to rely heavily on the judgment of the design engineers." This is quoted approvingly by Wijayaratna (1987277) from the final evaluation of Gal Oya.

2. Mobilization of local knowledge and farmer participation in system management. Farmer involvement in the design process through group mechanisms no doubt improved the quality of Gal Oya rehabilitation work. At the early stages of the redesign process, each of the farmer groups had two rounds of meetings with the design

engineers. Later, due to time constraints, these group meetings were replaced by walk-along-the-channel meetings between fanner groups and design engineers. Fanner organizations are now said to be functioning as real organizations with viable operating structures and continuous records of their efficient involvement in water management.

3. Computer model for system operation. There is no doubt that this has been helpful in enhancing the efficiency of water scheduling and operational decisions. However, this will not compensate for inadequacy of data on extents cultivated under different off-takes and on drainage.

The following constraints are identified and discussed

1. Unrealistic assumptions during the planning phase. In the author's opinion, one of the major gains expected by the sponsoring agencies from the proposed farmer organizations was to get farmers to take responsibility for rehabilitation work in the field channels. However, farmers were never consulted about this in advance and no agreement was reached before hand.

2. Inadequate data. For example, the lengths of different categories of channels were not known, much less the extent of cultivated area. Inadequate attention was paid to drainage, re-use and soil characteristics.

3. Limited impact of rehabilitation on production. As the direct major influence of the rehabilitation program is limited to system-wide improvements in water availability, such a program may not provide solutions to the non-water factors responsible for the yield gap.

4. Overseas training. Over the project period, 133 participants were sent abroad for short-term training and nine were sent for long-term training. Despite the fact that some of these contributed positively to the project's success, most were of very little value to the project or to water management improvements in the country as a whole.

5. The use of original design specifications in rehabilitation. The initial conception of the Gal Oya left bank rehabilitation was to restore the physical system to original design specifications. However, this was not possible because the latter could not be found. Some of the original specifications may not be appropriate for the changed conditions of the project -- the actual command area had increased significantly over the past three decades. Rehabilitation should provide an opportunity to benefit from changes in technology that have occurred since the inception of a project.

6. Coordination among line agencies. The work required by the local agencies (other than the Irrigation Department) to achieve the project objectives was not adequately defined in the project paper. In addition, lack of proper coordination and cooperation among agencies was observed to be a constraint during project implementation.

7. Limitations in benefit-cost evaluations of rehabilitation efforts. Calculations of benefits and costs in these studies (ex-ante and ex-post), depend on assumptions about the area that could be irrigated, the yields that could be obtained after the project is completed, the extent lo which the benefits are correlated with a project's implementation, and so forth. The difficulty in substantiating such assumptions has been demonstrated by the author. Benefit-cost evaluations, therefore, could be misleading at times. The internal rate of return calculated for the Left Bank system rehabilitation varied from 47.4 percent (ISTI 1985) to 17 percent (ARTI evaluation).

On the whole, Wijayaratna's paper is a very useful case study especially in planning for new rehabilitation efforts in other projects.

The final evaluation of the Gal Oya Left Bank Rehabilitation Project was conducted by the International Institute for Science and Technology (ISTI) in 1985. A six member multi-disciplinary team carried out the evaluation. The team's evaluation methodology included a review of available documents, interviews with USAID and government officials in Colombo, and a week long field visit to Amparai.

The overall assessment of the project is that, by any reasonable standard, the project as a whole has definitely been a success in spite of some mistakes made in the design and execution. The achievements listed are: I) a badly deteriorated major irrigation scheme has been rehabilitated in a cost-effective manner, and is operational; 2) formed and are functioning despite a fragmented social structure; 3) changes in agronomic practices, increased yields and increased cropping intensity, all due at least partly to improved water delivery and reliability, have combined with an increase in irrigated area to produce an internal rate of return of 47.4 percent.

ISTI (1985) concluded the project has substantially achieved its purpose of developing an institutional capability, which can be replicated to manage large irrigation schemes in Sri Lanka more efficiently and effectively with active farmer assistance. The capability and methodology developed at Gal Oya can and should be extended to other schemes, but this will require adaptation to different physical and social environments.

One of the most important outcomes of the project is the change in attitude, communication and behavior among farmers and government personnel that has occurred at Gal Oya. All the available evidence points to a major change in this regard (see Merrey and Murray-Rust 1987). This is a very important project achievement and should not be underestimated.

The factors that contributed to the overall project outcome according to the review are: 1) the improved reliability of water delivery as a result of rehabilitation; 2) the Institutional Organizer program and the farmer organizations it created; 3) the leadership of the Project Director, who actively promoted communication by direction and by example; and 4) the training program (which Wijayaratna [1987] criticizes).

Ethnic disturbances have adversely affected the project and have retarded rehabilitation of the tail end of the system.

On the project strategy and components, the review contends that the strategy, as it evolved, was appropriate for the project's goals and purpose, but that it differed significantly from the strategy set forth in the original project design. The original project paper included: 1) an overemphasis on heavy equipment -- the equipment was provided, but utilization was very low and maintenance was a continuing problem; 2) an overemphasis on detailed planning and the preparation of master plans. The adoption of the pragmatic approach to design and construction, as suggested by the mid-term evaluation, was a key element in the successful rehabilitation; 3) an overemphasis on research and testing; and 4) the absence of a specific plan and specific funding for rehabilitation of distributary and field channels. Distributary channels and structures in field channels were provided for in the amendment to the project paper. Who would do the field channel earthwork remained unsolved. Both the original and the final strategy paid inadequate attention to maintenance.

Merrey and Murray-Rust (1987), based on interviews with two key Irrigation Department officials two years after the end of project evaluation, report that these officials confirm the general evaluation of the importance of the farmers' organizations and other institutional efforts in the rehabilitation project, the usefulness of the pragmatic approach to rehabilitation, and most important, the farmers' organizations' continued existence and operation.

Just as the MIRP was developed based on experience with the TIMP, with funding from the World Bank and other sources, the Irrigation Systems Management (ISM) Project has been developed from the experience with the Gal Oya

Project. The ISM Project has funding from USAID, and is designed to continue testing and improving the approach used for organizing fanners at Gal Oya, and to test a rehabilitation approach called essential structural improvements (ESI) that is thought to be even more cost-effective than pragmatic rehabilitation. The original project concept was in fact not as a rehabilitation project pa se, but as a project to develop a capacity and a process in the Irrigation Department to carry out continuous maintenance and upgrading of irrigation systems that would not stop at the end of the project. In addition, the project aims to strengthen the IMD's capacity to implement the INMAS program, particularly in developing strong farmers' organizations, and in developing a performance and financial monitoring capability. Implementation of the project has just begun.

Comparative Analysis

To date, Merrey (1987) provides the only attempt to do a comparative analysis of Sri Lanka's irrigation system rehabilitation and modernization experience. He describes an analytical framework for comparing the degree to which rehabilitation projects focus on institution-building, and applies the framework to six Sri Lankan rehabilitation projects, to test the hypothesis that those projects which build strong responsible farmers' organizations supported by management agencies responsive to the needs of these organizations are more likely to exhibit sustainable improvements in productivity and equity than those that primarily emphasize physical reconstruction.

Lessons Learned

1. The experience gained by an organization in implementing innovations in a rehabilitation project was utilized in making modifications in the design of a subsequent rehabilitation project.

2. Standard approaches to designing irrigation projects may not be appropriate for some rehabilitation projects, and innovative and pragmatic rehabilitation approaches may be called for. Design engineers should be prepared to innovate to suit the context of a project.

3. A mid-term evaluation by competent experts can lead to appropriate mid-course corrections and redirection of a rehabilitation effort. Un- realistic assumptions made during the planning and design phase with limited data can be checked and corrected.

4. Farmer involvement in the design process through group mechanisms can improve the quality of rehabilitation work; it can also lead to farmers taking greater responsibility for system O&M after rehabilitation.

5. The use of specially trained catalysts like Institutional Organizers (IOs) to develop farmers' organizations has had a very beneficial effect and has been adopted on a wider scale.

6. The projects reviewed vary considerably in terms of their emphasis physical improvements versus institutional strengthening. It appears likely that institutional strengthening is extremely important if physical improvements are going to be used effectively by farmers, and for long term sustainability of the improvements. However, thii questioh deserves further research as well.

Research Questions

1. What mechanisms can be developed to improve communication among agencies (even in countries such as Sri Lanka), donors, and other interested parties to spread the rehabilitation lessons learned in different projects?

2. Donors and lending agencies seem to have their own preferences for different mixes of hardware (physical rehabilitation of **a** system) and software (the organizational and institutional dimensions of a system). Questions are often raised on the appropriateness of the mix. More research is needed to help answer the question.

3. More specifically, in relationship to the question of hardware versus software, some literature suggests that systems require rehabilitation or improvement in part because of institutional weaknesses (ineffective organizations, poor farmer-agency communications, inadequate O&M resources). If this is so, what emphasis should be given to institutional strengthening, and how should this be related to physical improvements? Would institutional strengthening lead to more *sustainable* improvements in irrigation system performance?

4. The rehabilitation process, the decision making, and the interactions among the various interested parties, is an area which is not much researched and deserves greater attention, in order to understand better why rehabilitation projects are designed the way they are, and to suggest alternative approaches.

5. Some literature suggests that more appropriate methods are required for evaluating rehabilitation project options, and evaluating the long term benefits of such projects afterwards. What would be appropriate criteria for such analyses and evaluations, and what methods would be required to base analyses on such criteria?

RESOURCE GENERATION AND FINANCING

Introduction

Generating resources for irrigation O&M[2] is crucial to achieving the objectives of irrigation for several reasons. One concern is mobilizing sufficient resources to enable the desired level of O&M. According to Perera (1986), almost all major irrigation schemes in Sri Lanka have suffered from poor maintenance due to lack of sufficient funds during the past years. According to Gunesekera (1985), Rs 120 million (US$3.75 million) is needed per year for O&M of systems outside of the Mahaweli. The Irrigation Department budget allocation is only half this. The government cannot afford to pay full O&M costs and achieve other social welfare goals.

Perera (1986) **says** the farmers have been badly affected due to the poor performance of the irrigation systems as a result of inadequate maintenance. Goonesekera (1985) found poor physical maintenance to be the most important technical constraint in Phase I of the Kaudulla irrigation system. He attributed this to the decline in funds available for maintenance. The funds allocated for maintenance were primarily used for wages, travel expenses, and supplies. Only Rs 300,000 - 400,000 (US$9,375 -US$12,500) were available for actual maintenance, and this was not sufficient for even minor repairs.

As Small et al. (1986) concluded, the institutional arrangements for mobilizing resources also affect the performance of irrigation systems. These arrangements determine the incentives that irrigation agency staff have to provide good irrigation services. Another of Goonesekera's (1985) conclusions was the need to provide irrigation managers with financial incentives to provide good management. The institutional arrangements also influence farmers' willingness to participate in the O&M of systems through paying irrigation service fees and contributing labor.

Under conditions of water pricing, the irrigation charge can also provide an incentive for farmers to use water more efficiently. Karunanayake (1982) advocates volumetric pricing of water to promote more efficient use. He recognizes that this requires a great deal of control over the water to supply it on demand, and accurate measurement of the supply to each farmer. In some systems, charging on a volumetric basis would not be possible without major rehabilitation of the system. An alternative would be wholesaling water in bulk at the turn-out level and allowing the farmers' organization to distribute it and collect from individual fanners. This requires much less measurement, but viable farmer organizations are a necessity.

Historical Reviews

Thompson (1987) examined imgation financing policies primarily in the British period through a study of documents in the archives. Ordinance No. 14 of 1848 permitted the colonial government to charge six days of compulsory labor per year for repair and upkeep of roads and irrigation works. Ordinance No. 21 of 1867 introduced the first irrigation rate of British times. The purpose was to recover the cost to the government of improving irrigation facilities. Beneficiaries were required to pay the cost of a project in 10 annual installments. The amount was decided beforehand, and cost overruns could not be included in the rate charged. A maximum water rate of six shillings/acre/year was established, with maintenance and repairs to be undertaken and expenses defrayed by the government.

In 1872 beneficiaries were given a choice of paying the 10 installments or paying in perpetuity for interest on the capital cost plus maintenance. Under this option the annual assessment was not to exceed Re 1/acre or seven percent of the cost of the works. Annual payments could be in cash or kind.

Authorization to collect a *maintenance charge* was extended to government-aided works in Ordinance 42 of 1884. This applied in cases where the capital cost was being repaid in 10 equal installments. The in-perpetuity payment option already included maintenance costs. Funds were used to maintain the system from which it was collected. The maintenance charge was not to exceed 75 cents/acre/year and was due 1 April each year. Land could be repossessed by the government for non-payment of capital or maintenance costs.

In 1889 the maximum maintenance charge was reduced from 75 cents to 10 cents/acre/year with assessments to be revised every year. Movable property of defaulters had to be sold before land. In the 1890s a concern of the Central Irrigation Board was that collection of monies to be repaid to the Irrigation Fund was not being enforced.

Ordinance 10 of 1901 raised the maximum rate to be levied in perpetuity from Re 1 to Rs 2 per acre (to cover interest on capital expended and maintenance). The maximum rate for maintenance on systems that were being repaid in 10 installments was raised from 10 to 50 cents/acre. A four percent interest charge was added to total costs repayable plus the maintenance charge beginning at completion of construction instead of the end of the ten year repayment period.

By 1910 the Irrigation Department had 151,253 acres (61,236 ha) in major works. During that year it had expended Rs 10,999,149 on restoration or construction and Rs 2,151,208 on maintenance and repairs, and had recovered a total of Rs 1,046,632 in perpetuity and maintenance rates and Rs 14,674 in repayment installments.

In 1914 the Irrigation Department reported that the maintenance rate was Rs 1.07/acre whereas the government's cost was Rs 1.54/acre exclusive of staff charges, plant, etc. In 1915, the government recovered a maintenance rate that averaged 70 cents/acre.

The Committee on Food Production in 1919 noted that the program on new irrigation works had been virtually suspended during the past ten years because of government policy relegating the Irrigation Department to a revenue earning department with all operations considered from the perspective of commercial profit. It recommended that the

Irrigation Department be reclassified as a spending department and that the current irrigation rate of approximately Rs 2 be suspended for five years to stimulate rice cultivation; these recommendations were accepted.

An irrigation rates committee was established in 1926 to determine the mean maintenance rate of the systems maintained by the Irrigation Department. Two types of works were examined: 1) works whose repayment scheme was in perpetuity, and 2) aided works (where owners had agreed to pay the construction cost in annual installments plus an annual maintenance fee). It concluded that proprietors under the "perpetuity" works who had originally been assessed an irrigation rate of Re 1 were in a favored position. It also concluded that fanners in large schemes in the dry zone were unable to pay a perpetuity rate or a construction rate and maintenance rate of more than Rs 2/acre per annum due to production risks and labor scarcity. The committee recommended that rates be assessed on all irrigable land, not just that irrigated in a particular season. Land cleared from the jungle should not be charged a rate until after three years. Crop lands should not be sold for nonpayment of rates; these should be recovered by selling the crop or if there was no crop, by leasing the land.

Thompson (1987) presents data from 1869-1984, with the exception of a 20-year period from 1938-57 for which she apparently could not locate the data, which show that in most years there was some collection of irrigation fees. Even in the period 1970-77 when irrigation charges were supposedly suspended, there was some revenue.

Silva (1986) conducted a study of the evolution of policies relating to the recovery of water charges from farmers, covering the period 1931-84. This study, based on published and unpublished reports and documents of the Sri Lanka government, looks at this subject within the broad framework of rural development and land settlement policies.

Historically there was no tradition of making land and water available free of charge. *Rajakariya*, an arrangement whereby wages were paid in land and rent was paid in labor, was a system of reciprocal obligations between the king and the people. The British outlawed rajakariya, which destroyed the mechanism for maintaining irrigation systems.

Ordinance No. 32 of 1946 as amended by Act No. 48 of 1968 provides for:

1. the imposition of an irrigation rate upon lands benefited or to be benefited under any scheme;

2. levying of contribution in labor upon allottees and tenant cultivators and, where there are no allottees or tenant cultivators, the proprietors of those lands for the purpose of construction or maintenance of the irrigation work and for the payment on an irrigation rate by way of labor contribution; and

3. levying of special irrigation rates in respect of water derived by seepage, mechanical appliances or other special means.

In the late 1960s in negotiations with the World Bank for financing of the initial stages of Mahaweli, the government had agreed that after completion of the project an annual rate of at least Rs 40/acre of cultivated land would be charged. This became an issue in the general election of 1970, and it is believed that this went against the UNP in the election which they lost.

The SLFP government in 1970 announced in the first Throne Speech the abolition of irrigation rates and that the state would undertake restoration and maintenance of village tanks and minor irrigation works. This labor, termed *wewa rajakariya*, had formerly been the responsibility of the farmers. In place of irrigation rates, a Land Betterment Charges Law No. 28 to recover cost of irrigation was passed in the National State Assembly in 1976. This, however, was not implemented, and the government changed in 1977.

From 1978 under the UNP government, O&M costs were to be recovered through the following charges:

Rs 30/acre in major schemes with over 150 percent cropping intensity,

Rs 20/acre in major schemes with less than 150 percent cropping intensity and minor schemes with more than 150 percent cropping intensity, and

Rs 10/acre in other minor schemes.

According to Silva (1986), this policy was actually implemented for only a short period in 1981-83 in major schemes, but collections were minimal[3].

Regarding land taxes there have **been** two persistent trends: concern about laud revenue and large-scale non-**collection.** Currently, the government does not collect any land tax, and Silva argues that it never effectively collected land **tax.** He concludes that both in assessing the land tax and implementing its recoveries, the policies have been ritualistic.

Silva.(1986) concludes that the recovery of irrigation charges has also been consistently ineffective. The collection-*cost* has not been computed, but he argues that it would be higher than the meager sums collected. The charging of an irrigation fee has been a political issue, and many members of parliament have opposed it. He concludes that one of the reasons the government did not vigorously enforce payment of irrigation fees is that they were dealing with an impoverished peasantry which, due to low agricultural production, was unable to produce a surplus that would enable them to pay the fees. While the government has always provided the legal authority for charging beneficiaries a fee for irrigation, for several reasons, including its social welfare ethic, it has not enforced collections with any vigor.

However, now the climate regarding charging irrigation service fees has changed according to Silva

1. The government recognizes that systems must at all costs be properly maintained. The Kantalai Tank failure in 1986 drove home this point.

2. The government's resources are extremely limited. It has to borrow from international lending agencies. National policy regarding irrigation service fees is influenced by the policies of the donor agencies.

3. There is new thinking about the management and development of major schemes.

4. There is greater emphasis on forming farmer organizations

These factors have affected the development of policy concerning collection and management of the present irrigation O&M fee in the major systems managed by both IMD and MEA.

Study of Current Policy

The most comprehensive and focussed study on the current policy concerning resource mobilization for O&M of major irrigation systems is the *Study of Recurrent Cost Problems in Irrigation Systems* undertaken by Engineering Consultants Ltd. and Development Planning Consultants Ltd. for USAID (USAID 1985). This study was conducted in 1984 shortly after implementation of the new O&M fee to be charged to all farmers benefitting from major irrigation systems whether under IMD/Irrigation Department or MEA management. The researchers reviewed relevant documents and interviewed officials in Colombo as well as in four major systems and a sample of 94 farmers in these major systems.

Based on a study in 1981 of 16 selected irrigation systems -- one in each range -- the Irrigation Department estimated that on average Rs 200/acre (about US$15.40 per ha) was needed annually to operate and maintain major systems. (Earlier it had estimated the cost at Rs 80/acre, or about US$6.00 per ha.) A high proportion of this cost is for labor because the Irrigation Department has a large labor force. The actual cost in a particular system may deviate considerably from Rs 200.

In the government's opinion, it could not provide adequate funding for O&M, and a policy was adopted that farmers should be responsible for full cost of O&M, but none of the capital or rehabilitation cost. An O&M fee of Rs 100/acre (about $7.70 per ha) of asweddumised paddy land per year was introduced in 1984. This is not considered a water charge or levy to recover cost of construction or rehabilitation. It is an annual contribution that farmers are required to pay for proper O&M of major systems. The balance of the O&M cost was to be allocated by the government through the normal budgetary process. The initial policy called for the O&M fee to be increased by Rs 20 each year for five years, whereupon farmers would be paying Rs 200/acre, the estimated full cost of O&M. According to the study, the differences between this fee and past policies were:

1. The amount of the charge was based on the actual cost of O&M;

2. It was not considered an irrigation rate or water charge, but a contribution farmers were expected to make to maintain systems in good condition; and

3. Funds were earmarked to be spent in the system from which they were collected,

The agency responsible for collection of the fees in systems managed by IMD/ID is the government agent (GA) of each district. He uses field officers of the Land Commissioner's Department such as colonization officers and field instructors to do the actual collecting, Collection of O&M fees is based on a Specification Register for each irrigation system, prepared under supervision of the GA. It gives the name of the legal allottees and tenant cultivators, extent of their paddy holding in the system, their location, and other relevant particulars. This register is intended to include all irrigation beneficiaries, including settlers in *purana* villages and regularized encroachers. Unregularized encroachers pay a fine of Rs 125/acre/year. It is unlikely that any of the Specification Registers are accurate and up-to-date. Instructions were issued to up-date them.

Fanners are informed by the person doing the collection of the areas for which they should pay Rs 100/acre. Post cards are sent as a reminder. Collections are first credited to an account in the bank branch at the nearest Agrarian Services Center. The District Kachcheri maintains a record of all collections deposited in the bank branches as does the main district bank.

These funds are not credited to the government consolidated fund, but are reserved for the major irrigation system from which they are collected. Allocations are made annually by the Ministry of Lands and Land Development through the IMD for regular O&M to be decided upon at the system level in consultation with farmers and farmer organizations.

In Mahaweli systems, the unit manager under the supervision of the block manager and resident project manager collects the fees'. The authors conclude that MEA has achieved a higher rate of collection because only one organization is involved. In IMD/ID systems collection efficiency depends on coordination of different field **officers** from different departments.

The GA is empowered to file cases against farmers who do not pay and to recover the fee **as** if it were an outstanding loan owed to the government. He may also deduct the unpaid fee from payments made by government to a farmer for sale of produce or other purpose. In the case of cultivators of private land, the **GA** may seize and auction property to recover outstanding fees.

The study lists problems associated with collecting O&M fees including:

1. Farmers do not understand the purpose of the fee
2. Specification registers are not up-todate. Not all beneficiaries are charged the fee
3. Farmers are charged for incorrect areas
4. Some farmers get water, if at all, only in maha. They should not have to pay the same rate as those who get water for two **seasons.**
5. The fee is not waived in case of crop failure. The ministry maintains that farmers can insure their crop.
6. Maintenance cost is less than Rs 200/acre in some systems.

Perera, the first Director of the Irrigation Management Division, in a paper describing the INMAS program (1986) outlines the functions of IMD, the Project Manager, the sub-committee of the District Agriculture Committee, the Project Committee, the Farmer Organizations, and the Farmer Representatives. All of these play a role in the mobilization and allocation of resources for system O&M.

Perera points out several changes that have been made in the policy since its initial implementation. A decision **was** taken to limit the fee to Rs 100/acre for farmers cultivating two seasons per year and Rs 60/ acre for those cultivating only one season. **To** allow farmers to get used **lo** the idea of contributing to the O&M fund, it was decided to suspend for the present the decision to increase the fee each year by Rs 20.

Also it was decided to limit the collection of O&M fee to systems with more than 200 hectares. Systems smaller **than** that were considered too small to warrant the effort in collections. **In** these systems, farmers are encouraged to maintain the distribution network themselves with assistance from the Irrigation Department.

He presents data on collections compared to assessments in the years 1984, 1985, and 1986. The proportion collected has declined drastically according to these data. However, since it is not clear when collections were made – money collected in 1985 and 1986 may have been credited to 1984 collections if it was the first time a farmer paid -- it is not possible to tell whether the amount collected in a given year has actually decreased **as** drastically **as** it appears.

Gunesekera (1985) reports that although farmers were accustomed to receiving irrigation free of charge with no responsibilities for maintenance of systems, the early experience was that after proper explanation of the importance of the payment and the program, the farmers did not disagree with it. He reports that the following contribute to fanners' resistance to pay:

Propaganda against recovery. Some groups have actively campaigned against payment. This had been a political issue in the recent past and collection efforts had been half-hearted.

Lack of confidence in officers. A few corrupt and irresponsible officers have caused farmers to mistrust government officials.

Failure to take action against defaulters. Lack of action against defaulters in the past made farmers think they could get away with not paying. But according to Gunesekera they will be prosecuted under Section 78A of the Irrigation Ordinance in future.

Research Questions

Historical studies show that the government in Sri Lanka has always provided a legal basis for charging fanners for irrigation services. During the British period there was a policy that beneficiaries pay for irrigation services, including the capital cost at a subsidized rate. At least for part of the period, the Irrigation Department was intended to be a revenue earning department, and it was argued that this greatly inhibited the development of irrigation. At the same time there was a concern that considerably less than the full amount that was due was actually being collected from farmers.

Since Independence, the irrigation ordinance has always provided for charging farmers a water rate, but collection has not been vigorously promoted. The issue of irrigation rates has been and remains a political issue, and at times the government has followed a policy of not attempting to charge farmers for irrigation services.

With the implementation of the O&M fee in 1984, the government appeared determined to make up for the shortfall in resources for irrigation O&M through gradually transferring the burden of the full cost of O&M to the beneficiaries. The Silva (1986) study on implementation of the O&M charge was completed the same year in which the O&M fee was first imposed. There is, thus, limited information on the actual experience of collecting fees, managing the funds collected, and allocating and spending them.

Research into these aspects of resource mobilization now that there have been several more years of experience is needed to understand better both the process and the performance of mobilizing resources for O&M of major systems. Have the amounts paid actually been spent in the system from which they were collected? How are decisions about allocating the maintenance budget made? How much do farmers participate in these decisions? Have farmer organizations been able to take maintenance contracts? What is the relationship between the development of effective farmer organizations and the rate of resource mobilization from fanners?

What is the sanction process for farmers who do not pay their O&M fee? Is it effective? Karunanayake (1982) advocates the constitution of special Water Courts to adjudicate irrigation violations including failure to pay irrigation fees. He maintains the normal judicial process is too cumbersome to settle cases, and authorities are reluctant to prosecute violators.

Silva (1986) concluded that MEA achieved higher collection rates because of its unitary management structure. A comparative study of policies and procedures in MEA and IMD may be useful. Has MEA continued to achieve these higb rates? Are there differences in incentives for those responsible to collect fees to do so? Are there differences in farmers' incentives to pay?

Under the INMAS program, project managers seem to have a certain amount of latitude in the implementation of policies and procedures. The rate of fee collection varies among systems, and research into the practices in different systems may identify innovations which make available greater resources for more effective O&M.

Since the implementation of the O&M fee, what has happened to the overall level of resources made available for system O&M? Has the amount allocated for irrigation O&M from the general fund decreased?

What is the present estimate of the amount of resources needed for O&M? The figure of Rs 200/acre/year was derived from estimates made in 1981. Is that amount still adequate, or should it be higher?

The Department of Agrarian Services is responsible for systems up to 80 ha and the Irrigation Department and IMD for larger systems. However, a decision was taken not to collect fees from farmers in Irrigation Department systems of less than 200 hectares. The farmers in those systems are encouraged to maintain them under the supervision of the Irrigation Department. They may be left to their own resources, and the farmers have likely either developed means of maintaining them or they are deteriorating badly. Little research has been done on the O&M of these medium-scale systems.

The issue of wholesaling water at the turn-out or distributary canal level as suggested by Karunanayake should be investigated, Is it feasible? What technological and institutional improvements would be required to implement such a scheme?

NOTES

[1]This finding is in contrast with the pre-rehabilitation situation at Gal Oya, where greater inequalities were reported along the main canals and distributaries (Wijayaratne 1986b). The difference may relate to the fact that Kaudulla is a water-surplus system, while Gal Oya is water-short.

[2]The focus of this review and the ISM project is primarily on mobilizing resources for system O&M with less concern for the mechanisms for financing initial construction.

[3]This somewhat contradicts data presented by Thompson which show a sudden dramatic increase in revenues beginning in 1979 and continuing through 1983.

[4]The money collected in Mahaweli systems does go to a fund in Colombo.

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APPENDIX

A REVIEW OF LITERATURE ON ON-FARM IRRIGATION MANAGEMENT FOR UPLAND CROPS

C R Panabokke and I Balasuriya*

INTRODUCTION

In Sri Lanka the remains of extensive and elaborate tank (reservoir) irrigation systems in the dry north-central and southern regions is ample evidence of an ancient advanced hydraulic civilization. Beginning about the fifth century B.C. and extending up to about the 13th century **A.D.,** this civilization was centered on and sustained by irrigated lowland rice cultivation. In addition, during the rainy season, under shifting or 'chena' cultivation, rainfed upland rice, coarse grains, gram legumes, and oil and fibre crops were cultivated. The size and extent of the cultural monuments of this period strongly suggests a self-sustaining agro-surplus economy, rather than a ro-subsistence economy, built on the more fertile Alfisols of this region.

The absence of evidence of irrigated upland agriculture having been practiced on a sustained basis in the island over a span of nearly 2500 years should be noted. The only exception is in the North, where limited extents of Oxisols are irrigated from wells using groundwater from the underlying limestone acquifer.

POST-18TH CENTURY IRRIGATED AGRICULTURE IN THE DRY ZONE

The concept of irrigated agriculture up to the early 1960s was the supply of water for puddled rice cultivation on the less well-drained soils and maintaining standing water from seedling stage to maturity. Irrigation of other field crops in the command area was prohibited by the Irrigation Ordinance. The pioneering research done at the Dry Farming Research Station, Maha Illuppallama (located in the northern Dry Zone), during the period 1952-62 demonstrated the technical feasibility of dryland farming under rainfed conditions. More important. it focused attention on the potential of non-rice crops on the well-drained and imperfectly-drained soils of the Dry Zone (Abeyratne 1956 and 1963). Furthermore, the studies on hydrology and water consumption patterns of crops (Panabokke 1959). erosion and run-off characteristics of Reddish Brown Earths (RBEs) (Alles 1958) and a detailed study of the Dry Zone soils (Moormann and Panabokke 1961) helped to broaden the scope of irrigated agriculture to include all field crops and diversified cropping on irrigable lands.

LIMITATIONS OF THE LITERATURE REVIEW

The volume of research on the northern Dry Zone (DL1)* soils. hydrology, crop diversification, and irrigated agriculture over the past **30** years has not been matched in the southern Dry Zone. Hence, this review is based on information available from the former. However, despite the apparent similarities between the northern and the drier

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southern Dry Zone, the differences, even though small, may have significant effects on the water requirement of crops in the latter; particularly because the Kirindi Oya project extends into the southern semi-arid zone (DL5*).

THE DRY ZONE LANDSCAPE

The Dry Zone has an undulating landscape with a definite ridge and valley pattern. The northern Dry Zone (DL1) has relatively low ridges and broad flat valleys while the southern Dry Zone, due to differences in erosion, shows a less mature landscape with less broad valleys. In such a landscape the topographical position of the soils determine their hydrology, hence the cropping pattern, management, and irrigation regimes.

The soils of the Dry Zone are differentiated into a catenary sequence closely associated with the landscape. The convex upper slopes consist of well-drained Reddish Brown Earths, **RBEs** (Rhodustalfs). The middle slopes consist of imperfectly-drained RBEs, and the concave bottom lands are composed of poorly-drained Low Humic Gley soil, LHGs (Tropaqualfs), and varying extents of alluvial soils (Entisols). together with Saline/Alkaline soils. The important soil characteristics and soil management problems are described in various publications -- Joshua (1985), Panabokke (1967, 1978), and Somasiri (1981). For the Kirindi Oya area, detailed reconnaissance and semi-detailed soil surveys and land classification studies carried out by the Land Use Division of the Irrigation Department provide essential information for irrigated agricultural development. The soil survey and land classification reports are available at the Land Use Division, Irrigation Dcpartment.

CROP DIVERSIFICATION

The current major objectives for crop diversification are to:

1. Select and match crops for different topographical land classes to optimize water use efficiency and economic returns to farmers:

2. Prevent over-production of rice. considering that self-sufficiency in rice has almost been achieved; and.

3. Grow non-rice crops during the dry season (yala) when stored water in reservoirs is inadequate for rice cultivation

Three aspects of crop diversification require special attention: 1) the place of rice cultivation in the dry zone, 2) crop selection and potential returns. and 3) land preparation and on-farm water management.

The Place of Rice Cultivation in the Dry Zone

Upland Rice. The term "upland" rice in the context of the dry zone refers to dry-tilled, dry-seeded rice on bunded land with or without irrigation. In the coastal plains of the northern and eastern provinces there is no provision for irrigation. With the rains and consequent rise in ground water the land is saturated and the rice crop raised in standing water. This is referred to as "Manawari" or rainfed rice.

*DL1 and DL5 refer to the agro-ecological regions as demarcated in the agro-ecological map of Sri Lanka (1976)

The term upland rice can also he applied to bunded rice land with limited irrigation supply. These lands are located in the lower aspects of the topography in the broad inland valleys of the Dry Zone where the watertable remains at or close to the surface during the wet maha season. The land is dry-tilled with the first rains in October and rice. is dry-seeded, either broadcast or row-seeded without puddling. The crop is raised using rainfall and limited irrigation. This is locally referred to as either "dry sown" rice or "non-puddled rice cultivation. It is essentially confined ***to*** the imperfectly and podrly-drained soils.

Lowland rice. This is traditional puddled rice cultivation on poorly-drained LHG soils in lowland valleys, using broadcast sprouted seed or transplanting. The water supply is the seasonal rainfall supplemented with irrigation. Planting is generally done from late October to December. The crop is heavily dependent on irrigation from land preparation to maturity. In the major irrigation systems, puddled rice cultivation is practiced on both the well-drained RBE and the poorly-drained LHG soils.

Upland Rice Cultivation. The seasonal rainfall in the dry zone is erratic, unpredictable. and poorly distributed. Hence, pure rdinfed rice without supplementary irrigation is highly unstable with frequent crop failures of varying magnitude.

Alles (1967), working on rainfed rice research at Maha Illuppallama for five consecutive years (1962-66), reported highly variable yields of 1,530: 3,621; 408; and 2,040 kilograms per hectare (kg/ha) for each successive year. The main problems were poor rainfall, both in quantity and distribution. and heavy weed growth.

At Walagambahuwa, a typical northern Dry Zone (DL_1) tank village, owing to water scarcity a successful rice crop was obtained only once in four or five years. In this village the Department of Agriculture (DOA) undertook a cropping systems research program from 1976-81, with the objective of increasing water use efficiency and land use intensity. Upasena (1986). reporting on the findings, states that with dry tillage and dry seeding done prior *to* the main maha rains (i.e., September or early October, rather than the customary sowing in November to December), and with a short-term duration rice variety (3 month), sufficient water could he saved in the tank for raising in yala a second low water-consumption non-rice crop such as pulses. However. extending the findings to other areas through the Tank Irrigation Modernization Project (TIMP) did not prove popular among farmers (Ministry of Lands 1983; Abeysekera 1985). The main reasons were the high cost of dry tillage using tractors. heavy weed infestation and high cost of weed control, and uneven plant stand due to erratic early seasonal rains. In summary. the high cost and risks were unacceptable to small farmers.

Dimantha and Ranjith (1982) carried out a series of investigations at the On-farm Water Management Research Project (WMRP), Kalankuttiya. on cultivation and on-field water management of upland rice and non-rice crops. Short and medium duration rice varieties were grown in early maha (i.e. mid-September ***to*** late November) with the objective of making maximum use of the seasonal rainfall. The land was prepared with pre-irrigation, dry tilled and dry sown. It was found that considerable savings in irrigation water was possible. The water use efficiency for upland rice ranged from 5 kg grain/10^5 liters of applied water (a.w.) to 179 kg grain/10^5 liters of a.w. compared with 32-99 kg grain/10^5 liters of a.w. in the case of lowland rice.

The wide range in water use efficiency in upland rice, an indication of instability, was mainly due to fields where the yield was low owing to heavy weed infestation. Moreover, with the crops planted earlier there was a saving in water but the yields were low, ranging from 1,342-1.900 kg/ha. The crops planted later (i.e., late Octohcr to late November) used more water hut gave higher yields; 2,870-3,110 kg/ha (Dimantha and Ranjith 1982). The latter was most likely due to the crop heading and ripening during January and February when solar radiation is high.

Thus, there appears to be a trade-off between water use and yields. The seven day irrigation interval resulted in fields running dry and contributed to heavy weed growth and possibly to water stress as well. **A** three day water rotation would have been more desirable but could not be done owing to the design of the irrigation system Dimantha (1986), summarizing the work, stated that the results thus far (up to 1982) were not encouraging.

The use of unpuddled soil for upland rice results in high seepage and percolation (S&P) losses. For example, the **loss** from a dry ploughed field ranges from 200-1,000 millimeters per day (mm/day) while that for a newly puddled rice field and an old puddled rice field (RBE soil) are 70-120 mm/day and 10-20 mm/day, respectively (Table 1; Dimantha and Joshua, 1986).

Table 1. Seepage from channels and fields.

Site	Range of seepage rate, mm/day	m^3/day per km
Secondary channel		320- 1280
Newly puddled rice field (RBE soil)	70-12	700 - 1200
Old puddled rice field (6 years)	10 - 20	100- 200
Dry plowed field	200 - 1000	2000 - 10000

Source: Dimantha and Joshua (1986).

The S&P rates of good rice lands are 0-3 mm/day, while that of dual lands (i.e., rice and diversified crops in wet and dry seasons respectively, should be less than 8 mm/day) (Miranda and Panabokke 1987). Apart from being wasteful of irrigation water, upland rice cropping results in **loss** of soil nitrogen due to alternate wetting and drying of fields and increases susceptibility to blast disease (**P.** *oryzae*) owing to low silica uptake.

Chandraratne (1981), quoting the work of NEDCO and ACRES in the Mahaweli area, mentions that the net crop benefit/ha from upland rice is around 50 percent less than that from non-rice crops (dry foot) and lowland rice. Moreover, the water use efficiency of upland rice is also about 50 percent lower when compared with that of non-rice crops i.e. Rs 0.35 compared with **Rs** 0.75 per cubic meter of water.

Lowland rice cultivation. The technology for lowland puddled and irrigated rice culture on **LHGs is** well developed **and** known to farmers.

When the upper slope RBEs are irrigated a careful monitoring of the salinity level of drainage water is necessary to prevent salinization of the LHGs. Unless careful attention is paid to the management of the watertable and drainage in the LHGs, salinization could easily occur.

Crop Selection **and** Potential **Returns**

The information available on growing non-rice irrigated crops on RBEs and **LHGs** in the northern Dry Zone indicates a high potential for production and net income/ha on irrigated RBEs, especially **in** the yala season. Information on the more promising crops **is** given below (Dimantha and Ranjith 1982; Dimantha 1986; Somasiri 1981; Upasena 1982, 1986) and in Table 2

Chillie: A popular crop among farmers. Grown more successfully in yala on well-drained and moderately welldrained RBEs. The watertable should be kept more than 60 cm, preferably 1 meter, from the soil **surface.**

Soybean: A very promising crop for both yala and maha on RBEs. The crop has an appreciable degree of tolerance to “wet feet,” and could be cultivated in yala even on LHGs provided there is good drainage.

Vegetables: Brinjals, okra and tomato have given high net cash returns on RBEs in yaia.

Pulses: Cowpea (*Vigna sinensis*, yield **800-1,200** kg/ha), greengram (*Vigna radiata*) and black gram can be cultivated in yala and maha on well-drained RBEs.

Oil crops: Groundnut does well on the well-drained RBEs in yala and maha. A light irrigation may be required to lift the crop. Yield is around **2,000** kg/ha.

Other: Onions (shallots and “Bombay”) can be cultivated in yala on RBEs. This crop being shallow rooted (10 cm) needs frequent irrigation.

Table **2.** Crops suitable for diversification in relation to soils, land, and season.

crop	**Reddish Brown** Earth				Low **Humic Gley**	
	Well-drained		Imperfectly-drained		Poorlydramed	
	maha	yala	maha	yala	maha	yala
Rice (Lowland)					+	+
Rice (Upland)	?		+			
Chillies	+*	+		+		
Soybeans	+	+	+	+		+**
Groundnut	+	+	+	+		
Cotton	+	+		+		
Gingelly	+		+			
Cowpea	+	+		+		
Greengram	+	+		+		
Onion		+		+		+**
Sugarcane	t	+	+	+		
Tobacco	+	+	+	+		
Maize	+	+		+		
Vegetables	+	+		+		

+ - could be grown, - not recommended, ? - insufficient information; *to grow chilies on well-drained soils in maha, late planting is necessary and the water table should .not be more than **60** cm from the soil surface, preferably one meter; **deep drainage drains are essential.

Dimantha et al. **(1981)** showed that on irrigated RBEs during yala the net income from crops such as chillies, brinjals, and soybean is higher than that of rice. The net return (Rs/ha) for chillies and brinjals is Rs **25,456** and Rs **15,786** respectively, compared with Rs 6,400 for rice, as shown in Table 3.

Table 3. Average yields, costs, returns and water use of upland crops compared with rice during yala, 1980

	Soybean	Brinjal	Chillie	Rice
Soil	RBE	RBE	RBE	LHG
Yield (kg/ha)	2361	14213	1548	4840
Price (Rs/kg)*	4.95	1.65	25.30	2.37
Average gross returns (Rs/ha)	11688	23452	38905	11500
Average net returns (Rs/ha)	5459	15786	25456	6400
Average cost of production (Rs/ha)	6229	7667	13449	5100
Irrigation water use (mm)	427	132	671	1616
Water use index (kg harvested/10^4 liters**)	5.5	19.0	2.3	3.0

Source: Dimantha et al. (1981); *US$1.00 -approximately Rs 17 in 1981 and Rs 32 in mid-1988; **10^4 liters will cover 1 hectare to a depth of 1 mm.

It is also seen from Table 3 that the cost of production of rice (i.e., the initial investment by farmers) is lower than for other crops (e.g., Rs 5,100 per ha for rice compared with Rs 13,499 per ha for chillies). Perhaps this high cost of other crops. among other reasons, explains the farmers' attachment to rice cultivation.

The average net returns for the respective crops, the average range of water duty compared with rice, and the irrigation water use efficiencies are given in Table 4.

Table 4. Recommended diversified crops for irrigation schemes compared to rice, giving average net returns.

Crop	Average range of: Net Return (Rs)*	Water Duty (mm)	Water Use Index**
Yala, well-drained lands:			
Sugar cane	15000 - 25000	1000 - 1500	125 - 250
Chillie	15000 - 35000	500 - 700	200 - 400
Brinjal	15000 - 25000	500 - 800	200 - 300
Soybean	5000 - 15000	250 - 450	75 - 150
Cotton	5000 - 20000	250 - 450	125 - 425
Yala, poorly-drained lands:			
Rice	6000 - 15000	1200 - 1500	50 - 100
Maha, well drained lands:			
Soybean	2500 - 6000	50 - 100	100 - 300
Maha poorly-drained lands:			
Rice	5000 - 10000	600 - 750	60 - 100

Source: Dimantha and Ranjith (1982); *US$1 - Rs. 28; **Rs. net return/10^5 liters applied water, 10^5 liters - *one* ha covered by one cm of water.

Studies on the economics of diversified cropping under irrigation were carried out by IIMI at Dewahuwa and Kalankuttiya (Mahaweli area) in 1985 and 1986 yala (Panabokke et al. 1987). The findings show that non-rice crops such as chillies, greengram, and soybean gave higher net returns (Rs/ha) than rice. Furthermore, the cost of production (i.e., the initial investment of farmers on chillies, the crop which gave the highest net return in Rs/ha), was two to three times that of rice -- Rs 8,386 and Rs 13,010 for chillies compared with Rs 3,661 and 4,339 for rice (Table 5). These data are consistent with those reported by Dimantha and Ranjith (1982) (Table 3). This reason, among others, may explain why some farmers are reluctant to non-rice crops. Moreover, a study of cropping in relation to drainage conditions in yala 1985 and 1986 indicates that farmers' decisions on crop selection takes into consideration the importance of soil drainage conditions; see Table 6. Similar results were obtained at Kalankuttiya as well.

Table 5. Crop costs and returns, yala 1985 and 1986, Dewahuwa.

	Rice	Chillie	Greengram	Soybean
1985 Yala				
No. of farms	35	41	42	14
Average area planted (ha)	0.37	0.47	0.37	0.36
Reported yield (kg/ha)	1300	900	600	1400
Gross returns (Rs/ha)	4968	27351	11772	12177
Production costs (Rs/ha)	3661	8386	3852	3232
Net returns (Rs/ha)	1307	18965	7920	8945
1986 Yala				
No. of farms	30	35	49	35
Average area planted (ha)	0.41	0.34	0.31	0.41
Reported yield (kg/ha)	2292	1073	751	1853
Gross returns (Rs/ha)	7814	26265	12848	16863
Production costs (Rs/ha)	4339	13010	5682	4098
Net returns (Rs/ha)	3475	13255	7166	12765

Source: Panabokke et al. (1987); US$1.00 - Rs 28.00.

Table 6. Crops planted under different ditions yala 1985 and 1986, Dewahuwa.

	Well-drained		Intermediate		Poorly-drained	
	1985	1986	1985	1986	1985	1986
Area of sample farms (ha)	17.2	21.1	28.5	17.0	8.0	15.1
Area planted to rice (%)	1.7	3.7	30.5	28.4	60.0	43.2
Area planted to OFC* (%)	98.3	96.3	69.5	71.6	40.0	56.8
Chillie (%)	52.9	28.4	28.1	25.4	26.3	10.0
Greengram (%)	37.3	31.8	30.5	29.4	7.5	23.9
Soybean (%)	8.1	36.2	10.9	16.8	6.2	22.9

Source: Panabokke et al. (1987); *OFC - Other food crops.

It was found that with rice cultivation the yields of head enders could be significantly higher than those of tail enders. However. with chillies the differences were not significant. Therefore, tail enders could be encouraged to grow chillies where they do not receive sufficient water for rice provided drainage conditions are not limiting. However. chillie being a long-duration crop (140-160 days). the total water requirement is about the same as for a 3-month rice crop and therefore would not save irrigation water. This study also revealed that rice yields in yala were around 2.5 tons/ha, but could be as low as 1.3 tons/ha (Panabokke et al. 1987). This also is consistent with earlier findings (Dimantha and Joshua 1986).

On-farm drainage. For successful and sustained crop diversification and also for lowland rice cultivation, efficient drainage to prevent waterlogging and for maintenance of optimum watertable heights is as important as irrigation. The poor yield of sugarcane due to waterlogging at the Sugarcane pilot project. Kantalai (Somasiri 1981), together with the poor *performance* of *non-rice crops and even lowland rice with waterlogging*, is clear evidence of the importance of providing good drainage. Hence, drainage should receive much greater priority and attention than in the past. In fact, Somasiri (1981) has suggested that in the development of new areas the drainage improvement should precede irrigation work.

Land Preparation and **On-farm** Water **Management**

The Dry Zone has an undulating topography. In the present practice of land development, bulldozers do the rough grading of the land end the farmers do the final development by making individual flat hasins. In the final land preparation farmers lay out basins and level the individual basins. Because of the undulating and uneven land surface. the numher of individual basin per hectare range from 40-400 with each hasin having its own average elevation. This is detrimental to the practice of efficient conventional surface irrigation methods except for flood irrigation for rice. Also. surface drainage is diificult under these condition. Based on field studies conducted at Kalankuttiya. Joshua and Knierini (1981) recommended Cross kvelled Graded Benches Terraces with a mild grade of 0.2-0.3 percent along the contour and zero slope across. A terrace width of 10-20 meters depending on the shape of the land and a permissible earth cut of 15 cni is recommended. Joshua and Knierim (1981) have also proposed a technique for precision shaping of land in small farms.

Among the different surface irrigation methods tried out at Kalankuttiya, good water control, farmer adaptability and high water use efficiency were achieved for the furrowed hasin system of irrigation for upland crops (Joshua 1980, Joshua and Knierim 1981). Basins of optimum size are constructed in the graded bench terrace with ridges and furrows within the basin, and each basin is irrigated by a field supply ditch separately. The basin dimensions, irrigation stream sizes, irrigation procedure and duration of irrigation are described by Joshua (1980).

Studies on on-farm water management carried out at the Maha Illuppallama research station, pilot project at Maha Illuppallama, Pelwehera. and Kantalai over the period 1972-80 have been reported by Somasiri (1981). Similarly, on-farm water management measures for the different soil and climatic regions of Sri Lanka have been described by Dimantha and de Alwis (1984). These include selection of crops in relation to soil and climate, agronomic practices, proper irrigation procedures and provision of adequate drainage.

The irrigation frequencies recommended for different crops on well- drained soils are given in Table 7.

The irrigation frequencies for imperfectly-drained and poorly-drained LHC soils are highly variable. Both the seepage from field channels and excess water application on the adjacent well-drained lands influence hydrological conditions in the imperfectly and poorly-drained lands. A definite interval between irrigations cannot therefore be recommended. Generally, three to four days more than the irrigation interval for well-drained lands may be required.

Table 7. Irrigation frequencies of crops on well-drained lands

Crop	Duration (days)	Frequency (days)	No. of irrigations required
Chillies	200	6	20
Cotton	135	8	17
Groundnut	105	8	13
Soybean	90	10	7
Black gram	85	7 - 10	7
Greengram	85	7 - 10	7
Cowpea	85	7 - 10	5
Onion	90	3 - 4	23

Source: Somasiri (1981).

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