

IIMI CASE STUDY NO. 2

The Kimbulwana Oya Irrigation Scheme: An Approach to Improved System Management

A. M. S. Sunil Gunadasa

INTERNATIONAL IRRIGATION MANAGEMENT INSTITUTE

Colombo, Sri Lanka.

IIMI
CS NO 2

Gunadasa, A.M.S.S. 1989. The Kimbulwana Oya Irrigation Scheme: An approach to improved system management. Colombo, Sri Lanka: IIMI, x, 52p. (IIMI case study no. 2)

/ irrigation efficiency / farmers' attitudes / farmer-agency interactions / farmer participation / rehabilitation / water distribution / irrigation management / benefits / farmers' associations / case studies / Sri Lanka /

DDC: 631.7

ISBN: 92-9090-III-X

Summary: This case study describes the problems which existed in the scheme prior to its rehabilitation in 1979 and the associated irrigation management innovations introduced by the author, who was assigned as a technical assistant by the Irrigation Department that year. Some of the management innovations included the provision of a simplified form of technical guidance to farmers and using organized farmer participation in the operation and maintenance of the system through a Water Issue Board. By gaining the confidence of the farmers and the various line agencies working in the area, the author was able to introduce a systematic rotational distribution of water, advance the cultivation calendar, and increase cropping intensity. He was also able to motivate the farmers to take over the responsibility for the maintenance of the system from the government, and to continue to improve the physical and operational condition of the system.

Please direct inquiries and comments to:

**Information Office
International Irrigation Management Institute
P.O. Box 2075,
Colombo, Sri Lanka.**

Responsibility for the contents of this publication rests with the author, August 1989. All rights reserved.

TABLE OF CONTENTS

	Page
LIST OF FIGURES	v
LIST OF TABLES	vii
FOREWORD	ix
EXECUTIVE SUMMARY	xi
ACKNOWLEDGEMENTS	xiii
INTRODUCTION	1
Physical Layout	1
Management Structure	3
BACKGROUND	3
History	3
Settlers	7
State of the Scheme in 1965	7
State of the Scheme in 1979	9
Previous Management Experiments and Why They Failed	10
REHABILITATION: AN OPPORTUNITY FOR CHANGE AND IMPROVED MANAGEMENT	12
Rehabilitation	12
Involving the Farmers	12
Organizing the Work	13
Maintaining Discipline Among Laborer / Farmers	13
Benefits Derived from Farmers' Participation in the Rehabilitation	13
THE INTRODUCTION OF ROTATIONAL WATER DISTRIBUTION	14
Demonstration of Proposed Rotation	15
Farmers' Initial Disapproval of Rotational Distribution	16
Farmers' Petition to Stop Rotations	17
Adoption of Water Issues	18
Formation of Water Issue Board	20
Water Issue Board and Kanna Meeting Decisions	21
Procedures for Making Water Issues	21
Farmer Leaders	22
ADVANCEMENT OF THE CULTIVATION CALENDAR	22
Necessity for Advancing the Cultivation Calendar	22
Analysis of Pre-1979 Maha Cultivation	23

Analysis of a Pre-1979 Yala Cultivation	24
Procedure in Facilitating the Advance of the Cultivation Calendar	24
1979 Maha Cultivation	26
1980 Yala Cultivation	27
Organizing Farmers for a Third Crop (1982/1983)	28
Seasonal Planning and Monitoring of Planned Issues	30
BENEFICIAL EFFECTS OF IRRIGATION MANAGEMENT INTERVENTIONS	33
Savings in Farmers' Time	33
Equitable Distribution of Water to Farmers	35
Increase in Cropping Intensity and Yields	35
Increase in Agricultural Inputs to Enhance Returns to Farmers' Investments	36
MAINTENANCE OF THE WHOLE SYSTEM BY FARMER ORGANIZATIONS	36
Initial Maintenance Work of Minor Irrigation Schemes by Farmers	36
Approaches Made to Kimbulwana Farmers to Take Over Essential Maintenance	
Work in Field Channels	37
Benefits of Farmer Participation in Operation and Maintenance Activities	37
Organizing Farmers to Maintain the Whole Irrigation Distribution System	38
Procedures Undertaken to Facilitate Farmers' Maintenance of the Entire	
Distribution System After May 1984	38
Nature of Maintenance Work	39
LESSONS LEARNED AND RECOMMENDATIONS	40
Lessons from the Various Interventions	40
Recommendations	41

LIST OF FIGURES

	Page
1. Layout of Kimbulwana Oya Irrigation Scheme Distribution System	2
2. Kimbulwana Oya system — management structure	4
3. Issue tree digram of the Kimbulwana Oya Irrigation Scheme	5
4. Map of Sri Lanka showing location of Kimbulwana Oya scheme	6
5. A typical field channel section	8
6. Farmer encroachment on channel bund-reservations	8
7. Timetable of the water issue program	19
8. Reservoir depletion graph for 1976 yala season	25
9. Reservoir depletion graph for 1982 maha season	31
10. Reservoir depletion graph for 1983 yala season	32

LIST OF TABLES

	Page
1. Composition of Water Issue Board	20
2. Performance analysis of yala season	34
3. Performance analysis of maha season	34
4. Average yields, t/ha (bu/ac)	35

FOREWORD

The Kimbulwana Oya Irrigation Scheme is known as one of the more successfully run irrigation schemes in Sri Lanka. The success story of the scheme has been featured in a video film produced under the auspices of the US Agency for International Development. This film made IIMI staff aware of the scheme, and prompted their initial visit to it in early 1985. It became obvious during the visit that it was mainly the dedicated effort of the Technical Assistant, Mr. Sunil Gunadasa, that was responsible for the improved management of the scheme. His answers to questions posed to him provided insight on the unique role he played from the time he joined the scheme in 1979 when it was about to be rehabilitated again. His story was substantiated by the Colonization Officer, the elected Chairman of the Water Issue Board, and some farmer representatives to the board. The board was a body organized by Mr. Gunadasa, which met weekly to decide on all irrigation issues faced by the farmers and the scheme management. These issues ranged from punishing farmers who violated board decisions to planning seasonal cultivation and seeking appropriate assistance from higher officials of various service departments.

Subsequent visits served to verify further improvements in the scheme's management. The physical condition of the scheme, instead of deteriorating was in fact improving. The well-organized farmers had recently taken over the maintenance of the whole scheme, which meant savings for both the government and the farmers. These observations were convincing enough for IIMI to invite Mr. Gunadasa to document his innovative approach to improved irrigation system management through the Special Awards program of the Institute.

Mr. Gunadasa is the second IIMI Special Award recipient. These special awards are given to irrigation professionals who have developed and implemented successful innovative approaches to improve the performance of irrigation systems. The Institute provides assistance not only in documenting but also in publishing and disseminating widely the innovative experience to an international network of irrigation professionals.

Senen M. Miranda
Colombo, Sri Lanka.

EXECUTIVE SUMMARY

History reveals that Sri Lankans have been honored for their great feats in constructing and managing irrigation reservoirs for hundreds of years.

The text highlights the fact that negligence regarding important aspects of communities after mass settlements in 1957 has resulted in the deterioration of irrigation systems. This is shown by the necessity to rehabilitate irrigation systems frequently. Millions of rupees that have to be spent on rehabilitation could be utilized in constructing new systems.

The following aspects are discussed at length to give a clearer understanding on:

1. The nature and level of expenditure incurred by the government in restoration work;
2. The hopes that settlers and landless people have of benefiting from the system in beginning a new life that will lead them to prosperity; and
3. The lack of technical guidance and coordination which led to the ruin of the entire system making it an unpleasant place for the community to live in and for government officials to work in.

The administrative structures tried out and the reasons for their failure are described.

Technical personnel who take pains to understand the problems in the system can, with innovative approaches, build up their credibility and gain the confidence of farmers by providing a simplified form of technical guidance to the farmers. This guidance can be in the form of information on water saving using rotational distribution of water based on a timetable, where water is reliably and equitably distributed to all the rice fields irrespective of their location — whether at the tail, middle or head end of the system.

Large amounts of water can be saved during the wet season by advancing the cultivation season, and using whatever stored water is left at the end of the season to overcome deficits in the dry season. Cropping intensity can be increased from 100 to 200 percent if more assured water is available.

The confidence of farmers can be built up gradually by analyzing available irrigation scheme data regarding rainfall, inflow, water deliveries, and storage in seasonal planning of cropping patterns and water deliveries during critical crop growth stages. Farmers could be guided to comply strictly with cropping calendars having up to three cultivations a year.

Considering the importance of farmer participation in the planning, implementation, and construction of systems, a controlling body composed of elected farmer leaders representing the entire farmer community, and government officers to guide them, was formed. The farmer leaders were the communicating medium between the farmers and government officers in seasonal planning, cropping patterns, and maintenance of systems. Conflicts and disputes were settled by a controlling body called the *Water Issue Board*, which met regularly every Tuesday.

The coordination helped farmers increase their yields and cropping intensities, and save time so that they could get involved with more income generating activities.

The confidence instilled in the farmers made it possible for a government maintained system to be converted into a major communal irrigation system where organized farmers undertook the maintenance of the system, thereby saving government money that would have been spent on maintenance work.

The system, with its well-functioning distribution system, is in a much better condition now than after rehabilitation in 1979, and the benefits derived by the farmers clearly indicate that the efforts and sacrifices they made in the process were not in vain. Technical guidance, coordination, and farmer participation are essential factors supporting the sustainability of an irrigation system.

ACKNOWLEDGEMENTS

I am grateful to the Professional Development Program of IIMI and the Director of the Irrigation Department for providing me this opportunity to document eight years of work on innovative approaches to systems management in the Kimbulwana Oya Irrigation Scheme.

It is with great appreciation that I acknowledge the efforts of Dr. Senen M. Miranda for devoting time to discuss the text and for the encouragement rendered. The encouragement given by Drs. Panabokke, Rao, Groenfeldt, Wickham, Lenton, Merrey, and Raby, and Mr. Berthery are remembered with appreciation. Especially helpful were the comments received from Dr. Merrey on the draft manuscript and the thorough and careful editing done by Mr. John Colmey.

My appreciation is extended to Dewaki, the coordinating secretary, and to Ameeta, who patiently read through the hand-written text and typed in corrections over and over again.

The text is dedicated to my parents who prepared me physically and psychologically to withstand hardships in a useful venture; to my wife Surangani for cooperating with me for a decade to make this venture a success; and to all the officials, and Kimbulawana Oya farmer leaders and farmers who worked with me.

Finally, my thanks to the IIMI staff for the assistance given to me in connection with my housing accommodation, transport and supplies, and for the hospitality extended to me during my stay at the Institute.

AN APPROACH TO IMPROVED SYSTEM MANAGEMENT: A CASE STUDY OF THE KIMBULWANA OYA IRRIGATION SCHEME

INTRODUCTION

In 1979/80 the Government of Sri Lanka initiated the rehabilitation of the Kimbulwana Oya Irrigation Scheme in the Kurunegala District in the North-Western Province of Sri Lanka. The author, a government Technical Assistant (TA), was transferred to the scheme to oversee the rehabilitation and to improve the management of the scheme and direct the benefits of the rehabilitation to the farmers. In carrying out these activities, the author took advantage of the farmer interest in the rehabilitation activities to introduce, test, and demonstrate new ideas for operating and maintaining the scheme. Farmer participation in the rehabilitation work proved to be the first step towards their participation in the day-to-day operation and maintenance (O&M) of the irrigation scheme.

This case study presents the nature of the problems which existed in the scheme prior to rehabilitation and the associated innovations in management which were subsequently introduced. Experience gained through the introduction of these innovations and a number of recommendations for the improved management of similar schemes are also presented.

Physical Layout

The Kimbulwana Oya Irrigation Scheme encompasses a reservoir equipped with sluice gates to regulate the water supply to a network of channels. There are two main canals (Figure 1). The right bank canal irrigates 564 hectares (ha) through 2 branch channels, 1 distributary, and 54 field channels. The left bank irrigates about 100 ha of mostly *purana* (preexisting) lands and augments two minor irrigation tanks. All offtakes and turnout structures are equipped with sliding steel gates that can be locked. The field channels are laid out across the contour. Numerous drop structures have been constructed to maintain a gradient of 0.0004. Farm outlets consist of Hume pipes of 10 centimeters (cm) diameter. During rotational issues, outlets, which do not have gates, are closed with straw or grass plugs. Water issues are monitored using staff gauges located below main sluices and in the various channels. Staff gauges at the head of the channels facilitate the maintenance of proper discharges to the satisfaction of agency staff and farmers.

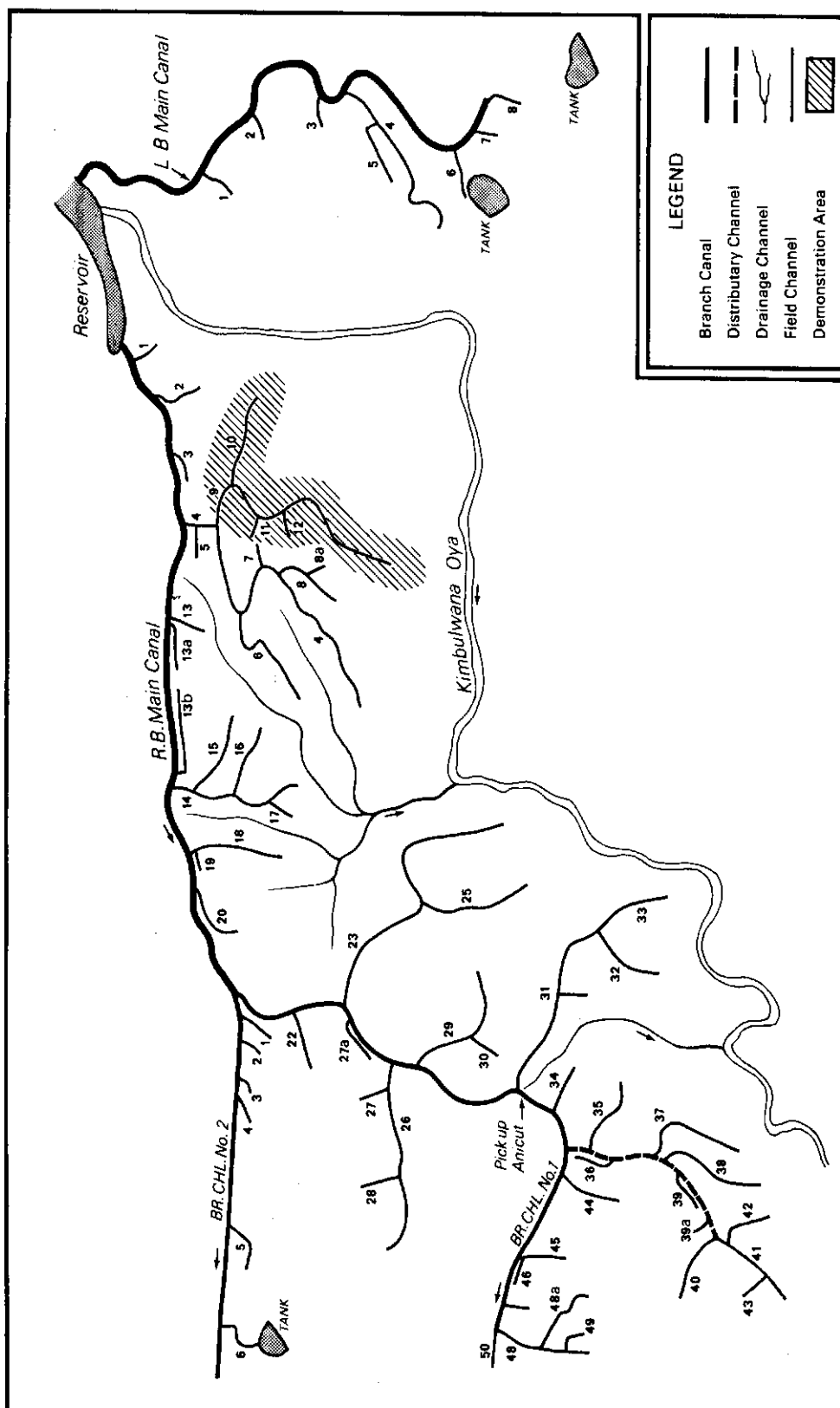
The undulating topography provides good drainage for the scheme. Due to the porous texture of the soils, seepage and percolation rates are high.

There are about 800 owner farmers and 200 tenant farmers. Farmers' plots average about 0.8 ha crown lands and 0.4 ha purana lands. Plots are located mostly along field channels and take water from farm outlets. Farmers generally grow two crops per year. In *maha* (wet season), from September to February, 100 per cent of the scheme is devoted to rice. In *yala* (dry season), from March to August, 80 percent is planted to rice, while 20 percent is planted to non-rice crops like chilies, greengram, cowpea, onions, vegetables, etc.

The area receives about 1780 mm of rainfall annually. The wet season (*maha*) rains average about 1320 mm. The convectional rains start in mid-September bringing in the first few rains. The rainfall intensity gradually increases with the onset of the Northeast monsoon during the second week of October with the heaviest precipitation occurring in November and decreasing during December. During the period between the end of December and the first week of January, the climate is ideal for grain formation when the nights are cool and the day temperatures are high.

In early April, convectional rains again begin to fall in the North-Western area of the region; the heavier rains occur by mid-April up to the end of May. About 460 mm of precipitation occurs during the relatively drier (*yala*) season. There is not much inflow to the reservoir but the scattered rains provide moisture to the *yala* crops throughout the season. The dry spell begins in mid-June with high day temperatures in July and August when harvesting is done.

Figure 1. Layout of Kimbulwana Oya Irrigation Scheme Distribution System.



Management Structure

The Kimbulwana Oya Irrigation Scheme comes under the jurisdiction of the Irrigation Department. A number of other government line agencies with district-wide responsibilities for agriculture, land settlement, agricultural services, and credit also service the farmers in the scheme.

Within the Irrigation Department an irrigation engineer is given responsibility for one or more irrigation schemes depending on the size of the schemes. In addition to general administration duties, he keeps track of the systems activities as time permits. In a small system such as Kimbulwana Oya, the responsibility of day-to-day O&M of the system falls to a government technical assistant who reports to the irrigation engineer. The technical assistant oversees a work supervisor who, with a few casual irrigation laborers, attends to essential maintenance work.

About two months before each cultivation season, the Colonization Officer calls a cultivation (*kanna*) meeting. The Colonization Officer is responsible to a Government Agent, a senior government official appointed to administer government services throughout a district. The meeting is attended by farmers within the scheme and by officers representing the various government agencies. The agriculture department officer explains the extension services and makes recommendations for the season. Officers from other departments submit additional relevant data and information which farmers need to plan their cultivation (new marketing schemes, seed distribution, and availability).

The president of the Cultivation Committee, usually a district land officer (see Figure 2 for organizational chart) or a representative of the government agent, then tries to gain a consensus from the group on a seasonal cultivation calendar. He requests the Irrigation Department technical assistant to present his assessment of the availability of water in the reservoir and the corresponding area that could be cultivated. As the *kanna* meeting is held prior to seasonal rains, sometimes the extent he recommends is less than 25 percent of the total extent. A decision is taken on condition that as soon as the tank storage reaches a certain level the cultivation will commence. Any other policy matters are also discussed at this meeting.

Representatives of each agency as well as a number of the elected farmer leaders also sit on a Water Issue Board. The Board meets every Tuesday and discusses issues such as a) fixing of an irrigation issue and availability of water in reservoir, b) irrigation difficulties and remedial measures, c) land disputes, d) crop diseases and preventive measures, e) agrarian inputs availability and supplies, f) unlawful activities related to violations of farmer meeting decisions and penalties imposed, and g) preseasonal planning.

Water distribution (see Figure 3) is done according to a timetable decided by a Water Issue Board. Decisions reached at the *kanna* meetings are followed strictly by the farmers. If not, the Board penalizes the farmer in question accordingly (described in detail in a later section).

BACKGROUND

History

The Kurunegala District in the North-Western Province of Sri Lanka has long been considered one of Sri Lanka's granaries (see Figure 4). It has provided food for a large part of the country for centuries. The Mahawansa records that Kimbulwana Oya Reservoir was one of the 16 tanks constructed by King Mahasen during his reign between 276-304 A.D. It was renovated by King Kashyapa during 937-954 A.D. and by King Parakramabahu the Great during 1153-1186 A.D.

After centuries of neglect and disrepair, the Irrigation Department, under the postindependence government, restored the reservoir. The restoration was completed in 1957, to provide irrigation to

The organizational chart of the Water Issue Board is structured as follows:

- GOVERNMENT AGENT** (top level)
 - ADDITIONAL GOVERNMENT AGENT**
 - DEPUTY DIRECTOR IRRIGATION**
 - IRRIGATION ENGINEER**
 - TECHNICAL ASSISTANT**
 - WORK SUPERVISOR**
 - PATROL IRRIGATION LABORER**
 - BANKERS REGIONAL MANAGER INSURANCE**
 - DISTRICT LAND OFFICER**
 - COLONIZATION OFFICER**
 - FIELD INSTRUCTOR**
 - DIVISIONAL OFFICER AGRARIAN SERVICES**
 - AGRICULTURAL INSTRUCTOR**
 - CULTIVATION OFFICER**
 - ASST. COMMISSIONER AGRARIAN SERVICES**
 - ASST. DIRECTOR AGRICULTURE**
 - K.V.S.**

- FARMER LEADERS -- (VIDANES)**
- FARMER ORGANIZATIONS**

Arrows indicate the flow of **GUIDANCE** (downward) and **INFORMATION** (upward) between levels.

Figure 3. Issue tree diagram of the Kimbulwana Oya Irrigation Scheme.

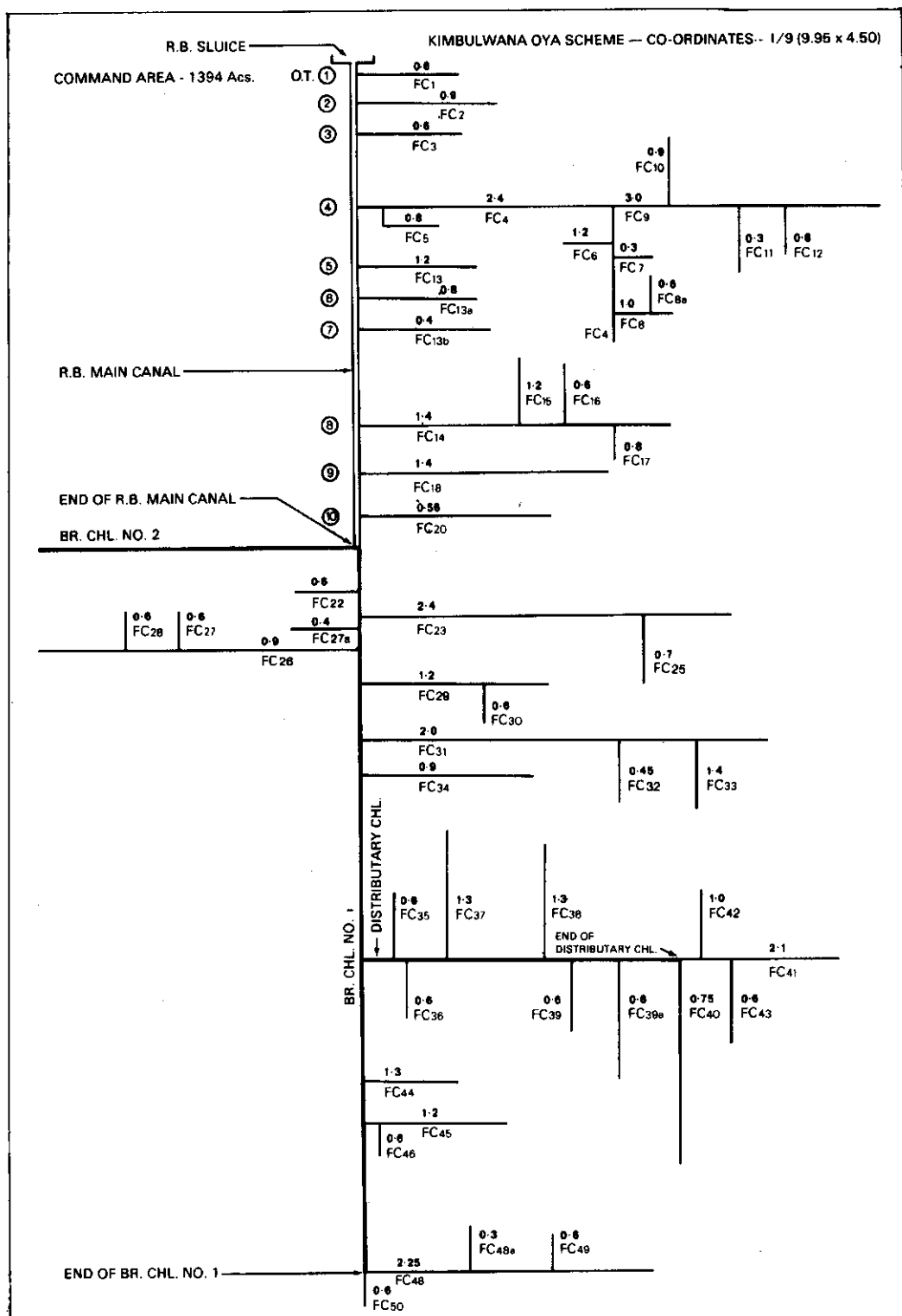
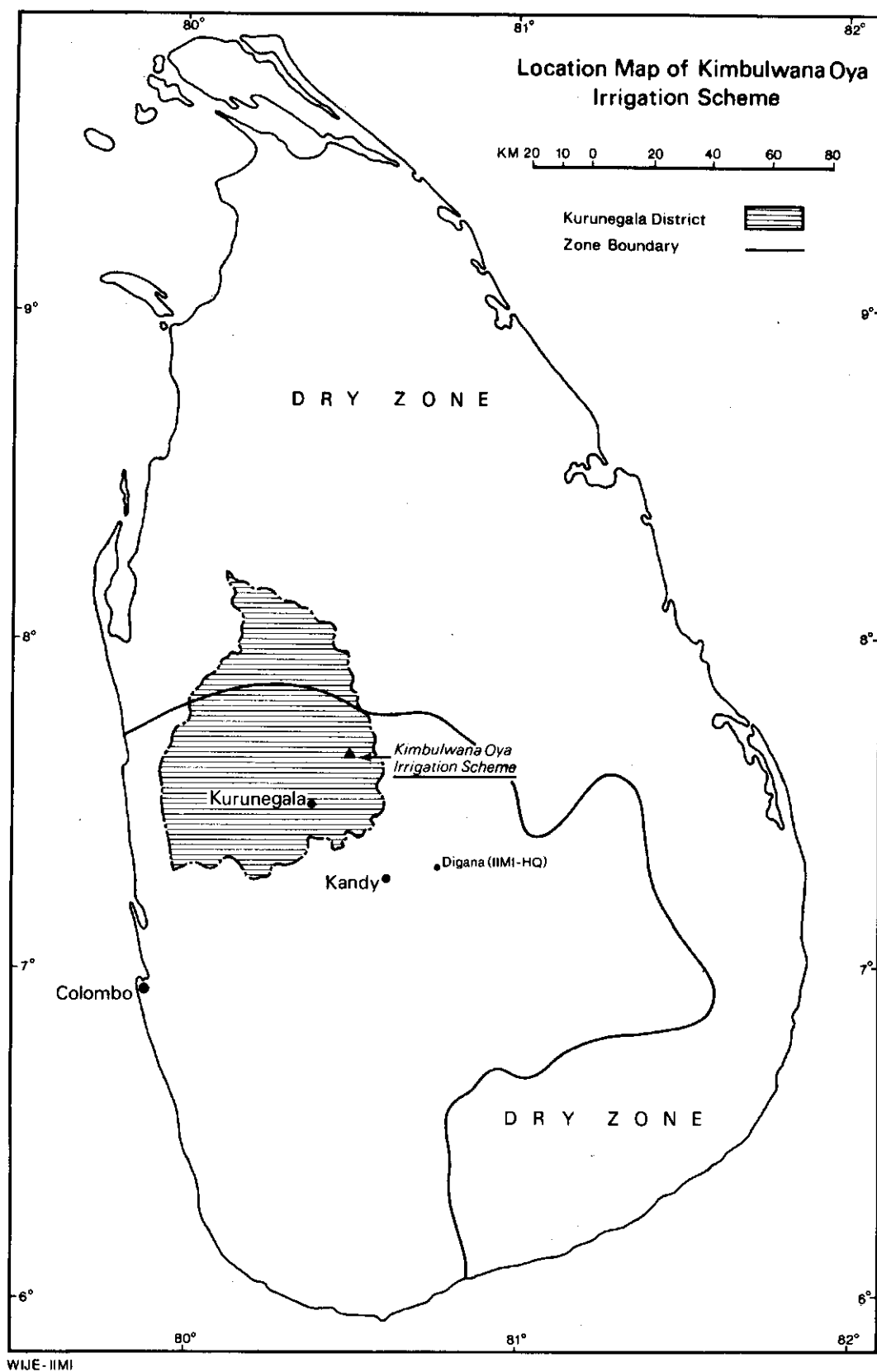


Figure 4. Map of Sri Lanka showing location of Kimbulwana Oya scheme



about 405 ha. In 1965, the tank capacity was increased to 629 hectare-meters (ha-m) by raising the spillway level by 1.22 m. This allowed for the irrigation of 458 ha under the right bank canal and 101 ha under the left bank canal. Two radial gates on the right spillway and lifting gates on the left bank were provided to facilitate spill discharges. The system was then allowed to fall into disrepair, and was rehabilitated again in 1979/80.

Settlers

Beginning in 1956, the government allotted 252 ha of paddy lots to 350 colonists, and 40 ha of purana lands, original settlement lands, were also cultivated. The majority of the settlers came from nearby villages within a radius of about 16 kilometers (km); the rest came from a few scattered villages in the Kurunegala District.

In general, settlers came with agricultural backgrounds and wide experience in farming. About 25 percent had possessed lands under minor irrigation tanks, about 50 percent had depended on rain-fed cultivations, and the balance had cultivated *chena* lands (rain-fed shifting cultivation). In most cases they did not own sufficient extents to provide the basic necessities for their families, due to the breaking up of family land holdings over time and through successive generations.

As in other colonization schemes, the settlers were reluctant to leave their villages due to family ties. Also, settlers from prestigious families did not like to be referred to as colonists. In some cases, settlers believed the new settlement areas to be infested with malaria. However, the settlers whose lands were submerged in the process of restoring the reservoir had no alternative but to accept the lands provided them near the tank.

State of the Scheme in 1965

By 1965, the cultivated area had increased to about 330 ha of colony lands and 61 ha of purana lands. At that time, the water supply was more than adequate. The average rainfall in the area was 1651-1778 mm: 559 mm during the yala season, and 1143 mm during the maha season. The catchment area was forested and had perennial streams flow throughout the season.

The population up to that time was composed mostly of bachelors or small families and the allotments available for cultivation were not fully cultivated until about 1965. Sufficient grazing pastures for cattle were scattered throughout the system. Most of the farmers near the headworks fed their cattle on the tank bed, an area of about 61 ha.

Up until 1965, the distribution system functioned smoothly. Every channel was built according to design specifications so that discharges could be made, and every channel had well-defined profiles and reservations to minimize seepage losses. The field channel design allowed a reservation width of 10 meters on the road side and 3.4 meters on the paddy-field side as shown in Figure 5. These reservation widths increased from 10 meters for distributary channels to 20 meters for main channels.

The settlers were united by their faith in Buddhism, which places great emphasis on the community. Settlers worked together and assisted each other on social occasions, such as funerals, weddings, and during cultivation in transplanting, reaping, and threshing. They all took part in religious activities in the village. Cultural presentations and other community events such as folk dances were also common during this period (1965 to about 1975).

Laws which governed equity and social relationships, as well as penalties for violating them, were implemented and imposed strictly and fairly. Government officials under various departments did their work conscientiously and could use their discretion in solving day-to-day problems. They were supported by their superiors who, in turn, enjoyed relative autonomy in running their offices. Political influence did not interfere in the operation of the scheme.

Figure 5. A typical field channel section.

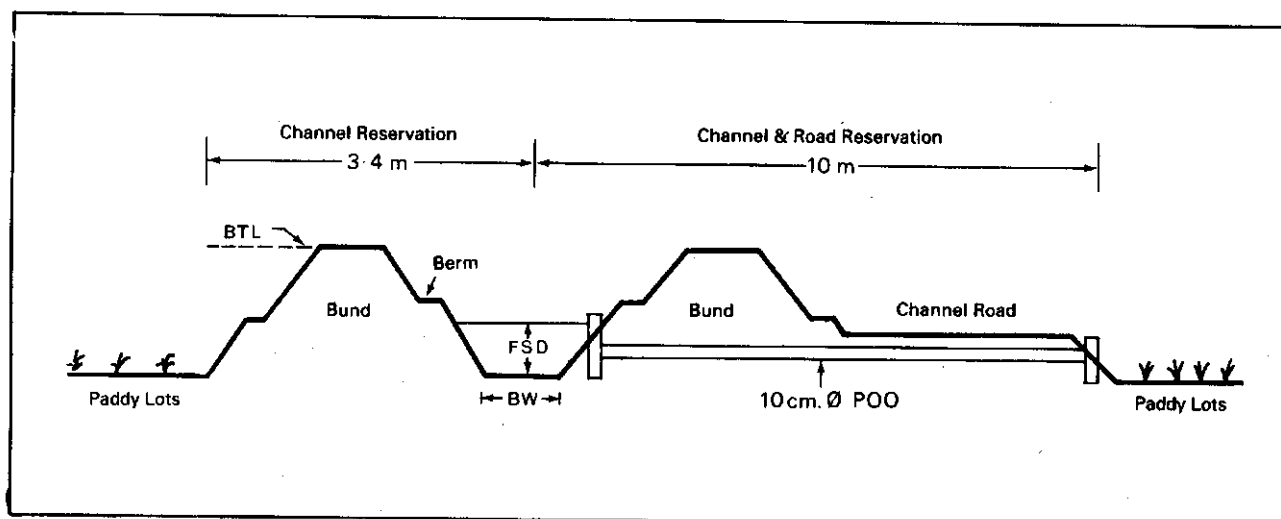
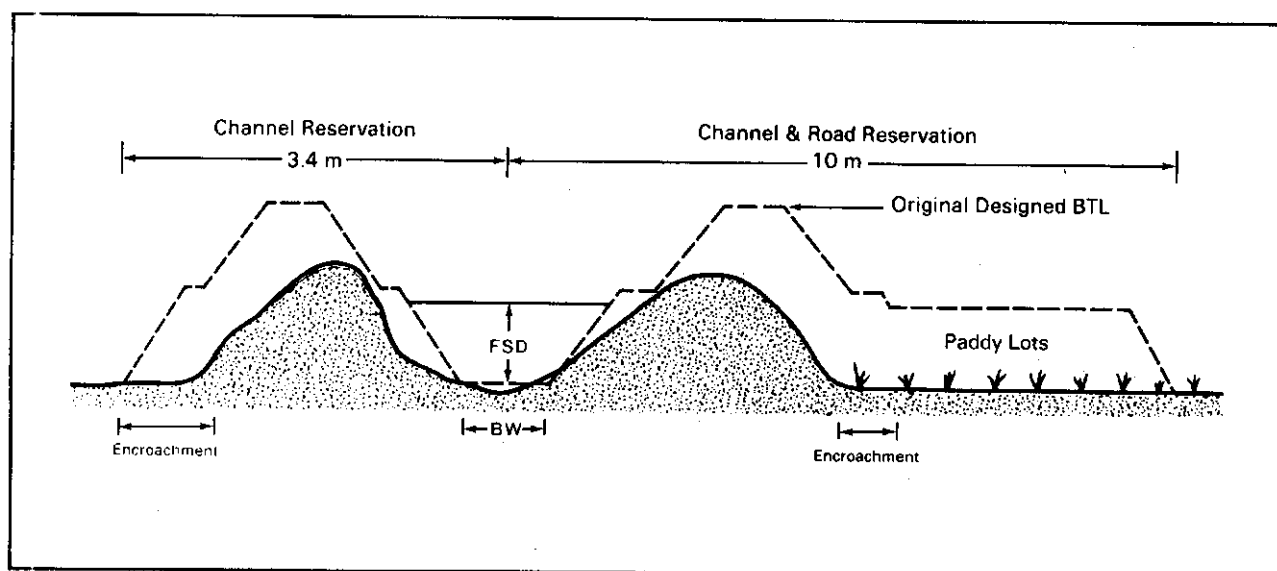


Figure 6. Farmer encroachment on channel bund-reservations.



State of the Scheme in 1979

Physical state. By 1979 the physical state of the scheme had deteriorated considerably. The canals had damaged bunds, scoured profiles, and eroded embankments. As a consequence, the canals' capacity to carry discharges (Q) was far below design. Maximum design Q could not be released through the channels without overtopping or breaching. Water supply at the tail sections was insufficient. Stray cattle were all over the channel system. Figure 6 shows how farmers encroached on channel bund-reservations which were designed to be 10 meters on the road side of the channel and 3.4 meters on the paddy-field side of the channel.

The few maintenance laborers available were unable to cope with the work load that accumulated daily. This included controlling the spread of weeds in the channels, desilting the channel beds, filling the scoured bunds, and operating the channel outlets during water issues. None of the wooden gates within the scheme were functioning. Most were damaged so that the locking devices failed to operate; 80 percent of the drop structures were undermined or else the water flowed around the structure, leading to insufficient head to move water to pipe outlets and to paddy allotments. Many of the channel regulators did not have control gates. Planned water issues to branch, distributary, or field channels, or to the allotments were impossible. This led to frustration among the officers and farmers.

Farmers' attitudes. Under these conditions, farmers became increasingly uncooperative. They were frustrated, helpless, and irritable. Yields decreased yearly, which reduced their incomes and increased their debt. Many farmers were forced to lease their land to raise the necessary income to meet their expenses and responsibilities (funerals, weddings, litigation, medical expenses, etc.). By 1979, more than half of the paddy allotments (each farmer had 0.4 ha of highland for his house and 0.81 ha of paddy land) were leased to outsiders. In addition, leases required that the farmer give a large portion of whatever water supply he received to the person who leased his land. They began to lose hope of earning a livelihood and became desperate in their outlook.

In general, farmers did not feel a sense of ownership of the scheme. They hardly attended to the maintenance of the system, and simply waited for the water to arrive at their lots. Farmers often expressed doubt as to whether enough water would arrive until the end of the season. Head-end yields were well below 3 tons per ha (t/ha), while yields in the tail end rarely exceeded 2-2.5 t/ha, even though the Department of Agriculture was distributing seed varieties with 5-6 t/ha yield potential.

Attitudes of government officials. Government officials attached to the scheme were cooperative in trying to improve yields through extension work. However, their efforts were rarely sustained due to the unreliability of the water supply.

It was apparent that government officials at the field level could not come up with solutions that were satisfactory to the farmers. There were a number of reasons for this: a) their authority was limited, b) problems evolved due to improper planning, and c) influential farmers often obtained favors through political means or even by means of intimidation.

Government officials were helpless in prosecuting them as the legal procedures for prosecuting offenders were cumbersome. Prosecution had to be done by the police, which meant that the irrigation officer had to travel 15 km or so to report the matter to the police station. A police officer then had to be brought to the scene, witnesses had to be gathered, and the damage had to be assessed. If everything was in order, the farmer was prosecuted in court. More often than not, after a long court trial, the farmer was acquitted or the case was dismissed due to the weak testimony of the witnesses. In addition, there were numerous incidents when field officers reported offenses to superiors, but by the time an inquiry was held, other cases took precedence.

Within the scheme officers travelled considerable distances to attend to normal duties. When

farmers reported interruptions or unlawful activities; the officers had to travel even farther, thus exceeding their allocated mileage and allowances. As the officers' salaries and allowances barely met their minimum expenses, they could not be blamed for not acting against malpractices. They were also careful to work within limits so as not to lose their rapport with farmers as well as with superior officers.

Effect on irrigation efficiency. Problems arose at the beginning of the season. During the kanna meeting, officers would recommend the acreage to match the available quantity of water. The farmers criticized the department for not providing them sufficient water and for not taking stern action against those who violated kanna meeting decisions. The kanna meeting provided the only opportunity for farmers to voice their complaints against the department.

During the wet season, farmers made it a practice to wait until the water supply was certain and would waste initial rains before starting land preparation and transplanting. These normally began in early November even though the maha seasonal rains would begin in late September and peak in mid-October. By that time some of the farmers would have completed part of the desilting of their field channels and the Irrigation Department laborers would have completed partial desilting of the main and branch channel systems. These efforts were rarely sufficient to make satisfactory issues.

The Department of Agriculture or extension services could supply only a small percentage of the required rice seed and fertilizers as the farmers' orders were too late; administrative procedures required about two months lead time from order to delivery. If the seeds did not come on time, farmers would use whatever varieties that were available. Different varieties with varying stages of growth increased the difficulty of water delivery and led to increased incidence of pests and diseases.

Because all the cultivation in the neighborhood of the scheme began in mid-November there was a conflicting demand for farm machinery, helping hands, and work cattle (used for land preparation). Often farmers were forced to wait until the influential farmers completed work on their plots, which were scattered all over the scheme.

Ultimately, the land preparation period decided by the farmers would have to be extended. Land preparation varied up to 56 days. By this time most of the inflow from seasonal rains would have ceased, which meant that the farmers had to utilize the tank storage for the balance of the initial season's cultivation.

When initial water issues for land preparation and transplanting stopped, the sluices would remain closed and subsequent issues made on farmers' request. Water was sent to the tail-end field channels first. There farmers would receive water for a short time, probably for half a day or so, and the flow would gradually cease as the farmers at the head end of the system tried to divert the flow to their fields. At night, tail-end farmers would go up the system in groups to search for and remove interferences thereby releasing water to the tail end. But on their return they would find the head-end farmers had again directed the flow to their lots. This led to a conflict over water issues, decreasing efficiency over the entire system.

Due to these malpractices farmers usually lost most of the tank storage. When it became clear that many farmers would not complete the season, officials resorted to fortnightly issues. The resulting water stress throughout the schemes led to a further decrease in yields.

Previous Management Experiments and Why They Failed

Vel vidane system. Prior to 1958, the government appointed a *vel vidane* (village headman) to be responsible for water issues and minor irrigation work. The *vel vidane* was selected from among the settlers, and therefore had access to and support from the farmers in carrying out improvement and maintenance work. He had the authority to prosecute, at the rural court, farmers who did not comply with the community decisions. In general, the *vel vidane* had only to make a request to the community to enlist beneficiaries under a minor tank to do maintenance work.

There were several advantages to this system. Minor irrigation tanks were maintained in good condition as the vel vidane carried out or supervised frequent maintenance work on the scheme. He was able to maintain discipline among farmers as he was accepted as an authority to prosecute offenses such as allowing cattle to stray, illegal water tapping, or violation of community decisions. And, as a member of the community, the vel vidane was able to develop a close relationship with the farmers.

However, in 1958 the system was abolished, primarily because of the shortcomings of individual vel vidanes. This was partly because the vel vidane received his authority from the government. He did not have to consult or seek guidance from a committee of elders and thus was not accountable to the farmers. When he made a decision, little room was left for others to intervene. Except for a few cases, the government awarded the post of vel vidane to an elder in the community whom people respected. Had he been better supervised, his service may have been of more use to the community.

There was another reason for this abolition. The post was created during colonial times when the village headman and *korale officers* (chief of village headmen) were functioning effectively. When these positions were abolished after independence, the vel vidane position suffered the same fate by 1958.

Govi karaka sabha (cultivation committee) system. After the abolition of the vel vidane system, the government established a system called "*govi karaka sabha*" (cultivation committee). The system was in use from 1958 to 1977. The committee included a few members from the community and comprised a president, secretary, a treasurer, and the usual office bearers. The secretary of this committee played a role similar to that of the vel vidane. The committee oversaw all village minor irrigation work, often on a contract basis.

The chief advantage of the system was the division of power among several community members. However, the system quickly became politically oriented. When the committees began to make extra money by doing inferior quality work in undertaking repairs and improvements, they lost the farmers' confidence. And the farmers became reluctant to seek the committees' assistance in solving their problems.

Had the government provided adequate supervision, control and guidance over the "*govi karaka sabha*," this system, like the vel vidane before it, might have succeeded.

Cultivation officers. The cultivation committees were replaced in 1977 by government appointed cultivation officers. Like the vel vidane they were chosen from among the community, though sought out for their level of education. Organizationally, they came under the divisional officers of the Agrarian Services Department who trained them to a certain extent. The cultivation officers were empowered to hold inquiries into village-level disputes and could lodge complaints through the Divisional Officer, who supervised them.

In addition to the advantage of living among the community, the cultivation officer had access to the various government departments such as those of Agriculture, Irrigation, and Highways (now defunct), which enhanced his ability to get work done on behalf of the community.

The chief disadvantage was again the tendency for cultivation officers to become politically oriented. The appointment of the officer tended to be political, as the access to government agencies carried with it a certain political power in the village. Supervisors found it difficult to maintain discipline among cultivation officers because of their vulnerability to political influence. Joint ventures at the village level rarely succeeded as officers tended to favor their villages. And there was a wide divergence in the individual performance of the officers.

REHABILITATION: AN OPPORTUNITY FOR CHANGE AND IMPROVED MANAGEMENT

Rehabilitation

As stated in the introduction, in 1979/80 the Government of Sri Lanka undertook the rehabilitation of the Kimbulwana Oya Irrigation Scheme. The scheme had to be rehabilitated to put it back to functional physical condition. The scheme had lost the specified levels of channels, embankments, and concrete profiles; structures had settled and cracked, rendering them useless. The initial allocation of Rs 3 million (about US\$ 136,000) for rehabilitation and construction work was reduced to Rs 1 million.

The author was transferred to the scheme as a government Technical Assistant (TA) to oversee the rehabilitation and to improve and sustain the management of the scheme. At the time of his arrival, only three months remained to complete the initial preparatory work and workplan. This involved making on-the-spot decisions regarding improvement and repair work to ensure that it would fall within the allocated amounts and produce a functioning scheme. New pipe outlets and cast-iron gates were installed on improvised existing structures. Essential repair work was done on existing structures.

Because the usual procedure in executing work of this nature was to execute it under a contract basis the author considered a number of factors in organizing the new rehabilitation effort.

First, over 95 percent of the rehabilitation work that had to be done on the distribution system could be attributed to a lack of farmer participation in operating and maintaining the system, to a lack of farmers' awareness as to the ownership of the system, and to a lack of coordination with the government sector in formulating policies and decisions to overcome minor conflicts. Thus, maximum farmer participation was considered essential if an appropriate and sustainable rehabilitation was to be carried out. This would also offer the opportunity to improve farmers' discipline.

Second, it was necessary to provide financing to farmers for their livelihood during the period when water issues had to be curtailed to execute the work. Thus, rehabilitation and repair and improvement work were planned to be executed in two stages. Stage one would take place during the 1979 dry season, from April to September, and cover that part of the system under the main channel and field channels 1-20. During this period, issues were curtailed in the Unit 3 area to about 344 ha. Stage two would take place during the 1980 dry season, and cover those parts of the system under branch channels 1 and 2, distributary channel 1, and field channels 21-50. Water issues were curtailed to an extent of about 324 ha.

Involving the Farmers

Due to the closure of parts of the systems, the author decided to employ the farmers to do the work. He also granted them permission to grow a subsidiary crop (peas and cowpea) on condition that this activity would not interfere with the construction work, and that the farmers would not try, illegally, to obtain water intended for Unit 2 area.

When the information spread through the community that the farmers would be employed in the construction work, over 400 registered as ad hoc type laborers. The TA carried out registrations at the Scheme's Unit Office for the convenience of the farmers.

Due to the widespread interest on the part of the farmers to take part in the construction, four times the required labor strength was available. It was important to show the farmers that the selection of laborers was conducted fairly. A number of steps were taken in this direction. First, the TA made a list of all available farmers. Second, the TA asked only the right number of farmers to work on dates when the Department needed them. Third as far as possible, an effort was made to accommodate those farmers with allotments under their respective field channels to work with the

department. Fourth, an effort was made to ensure that all the farmers in the Unit 3 area would get an equal number of days in the payroll so that they were treated and assisted financially in a fair way. Fifth, the TA refrained from hiring children, elderly people, and others whose output could not match the amount paid to them. Last, when professionals were to be employed as metal quarry laborers, masons, carpenters, and supervisors, the department was to be given the option to employ them irrespective of the area of their residence.

Organizing the Work

With over 80 percent of the structures in need of repairs, various types of work were necessary throughout the scheme, including: provision of downstream protection of structures to prevent them from being undermined and collapsing; the construction of drop walls to existing structures where settlements, owing to continuous leaks, had been detected; and the replacement of cracked or damaged field pipe outlets. And this is only a partial list of the multitude of repair work needed.

Labor teams were organized under competent supervisors. They had to expose every drop structure, where leaks were expected, to search for possible cracks and waterways, anthills and vents that were causing failures to structures. They had to excavate the foundation and remove damaged sections. A transport team followed and supplied the required amounts of metal, sand, and rubble at convenient places close to the structures that needed repairs. A concreting team followed with shuttering and concreting. The wetting of concrete, removal of shutterings, the transport of extra materials, the backfilling of structures and turfing, and other finishing up work was all done subsequently.

This approach had two advantages. The work was completed ahead of schedule. And farmers gained a greater awareness of the technical aspects of the systems, how deterioration occurs, and what was necessary to maintain the system.

Maintaining Discipline Among Laborer/Farmers

The organization of labor was done in such a way that no employee could leave the site without the supervisor's knowledge. The TA assigned one supervisor for every 50 laborers. Employees signed an attendance book on arrival and on departure. Attendance was marked in the morning and afternoon before and after the lunch break.

Movements of material were recorded when issued from main stores, during transportation, and on arrival at the respective field sites. Record was also kept of usage, balance at the end of the day, and materials returned to stores. All the custodians had to sign for accountability. The professional workers had to verify the usages at the end of the day. Hence, frauds and malpractices were avoided. Instructions received from supervisory staff and the quantity of work done were recorded in Log Books.

All those employed were treated equally, and disciplined when necessary. Wages were given to them at proper times, and festival advances, etc., were arranged despite the administrative inconvenience.

Benefits Derived from Farmers' Participation in the Rehabilitation

The strategy of using farmers who had paddy allotments under the field channels to repair the channels was very effective. This inspired the farmers to endeavor to find solutions to their existing problems, and they took an added interest, in the knowledge that benefits would accrue to them.

For example, farmers assisted the TA in preparing the estimates for repair work of the leaks in structures, especially where underground cracks, washways, and settlements were unforeseen. Although some of these structures were not specifically mentioned for repairs, farmers exposed these points so that remedial measures could be taken.

When earth-work required clayey core walls, farmers pointed out the fields where suitable materials were available, thus avoiding the use of sandy, inferior quality filling materials. In doing earth compaction work, farmers were keen to do a thorough job. In using concrete mixes of sand, metal and cement, farmers ensured obtaining the proper mixtures.

As most of the construction shifted from site to site, it was necessary to find temporary field stores to store tools. In these cases, farmers willingly took custody of the stores and kept them in their compact houses. This relieved the department of the burden of building temporary huts throughout the scheme. When tools such as crowbars, picks, axes, or adzes were in short supply, farmers willingly brought their own to use.

During construction, farmers observed that the embankments which were newly filled with turf were damaged overnight by stray cattle. In these cases the farmers cooperated with the department in setting down suitable preventive measures.

There were other benefits that resulted from farmers' participation, particularly in terms of minimizing wastage. During construction farmers took advantage of the opportunity to point out problems or show disappointment about: a) wastage of government property; b) collapse of foundations due to the delay in follow-up work; c) stoppage of work due to lack of transport; d) work postponement due to lack of supplies such as cement, steel reinforcements, cast-iron gates, blasting material, or shuttering planks; and e) work postponement due to lack of skilled manpower and professional workers like carpenters, masons, quarry workers, or supervisors.

In the presence of adequate labor strength more labor-intensive construction could take place. Instead of demolishing existing turnout structures and putting up new expensive replacements, the existing ones were improved and strengthened whenever possible. New cast-iron controllable components were incorporated in them. Lengthy retaining walls which were about to collapse and were scheduled to be demolished were underpinned with concrete work to put them in usable condition. Much of this would not have been possible without the farmers' participation, due to budget restrictions.

Last, considerable benefits accrued to the Irrigation Department in gaining a reputation for taking a genuine concern in the farmers' problems. Also, the procedures followed in organizing and carrying out the rehabilitation were incorporated in involving the farmers in the O&M activities to follow. Most importantly, their participation marked the first step in enhancing their feeling of ownership and responsibility for the system.

THE INTRODUCTION OF ROTATIONAL WATER DISTRIBUTION

Despite the successful rehabilitation of the scheme, the author recognized that a number of changes in the use and management of water would be necessary to increase yields to an acceptable level. Adequate water supply is not enough in itself if the water is wasted or is not applied in adequate amounts during critical stages of cultivation. Similarly, yield can be depressed if the cultivation season commences at the wrong time.

Other factors which lead to poor yields include the insufficient or inappropriate use of agricultural inputs such as fertilizers, weedicides, and pesticides. However, management of the water supply has the greatest influence on the crop yield, at least in Kimbulwana.

In 1979, the author undertook a study to find out the causes of the deficiencies in the water distribution system of the Kimbulwana Oya Irrigation Scheme. This involved determining the basic characteristics of water distribution in it.

The area specified for cultivation was 559 ha, all of which was used for rice. The total amount of

water used to irrigate once, as per tank sluice discharge, equalled 105-123 ha-m. The amount of water delivered on farm after subtracting 20 percent for estimated conveyance losses equalled 98.7 ha-m. This is equal to a depth of water of 0.17 meters or 17 cms over the total 559 ha. In other words, with the amount of water released from the tank, it was possible for every field to have 17 cms of water. And yet farmers were experiencing a water shortage.

Farmers were provided with 10 cm Hume pipe outlets to their 0.8 ha allotments. By having a head of water of 10 cm., a pipe outlet could deliver a discharge of 11.3 liters per second (liters/sec). If this discharge could be maintained for 12 hours, a 0.8 ha allotment could be irrigated to a depth of 7.62 cm. However, because the farmers were accustomed to receiving water simultaneously under a field channel over the entire system, no channel could deliver the necessary discharges to irrigate the entire extent under it.

To get a better understanding of this situation a *demonstration area* was selected in Unit 3 area under FC 4 turnout (see Figure 1), served by field channel no. 9 with an extent of 82 acres. A full supply discharge of 63.72 liters/sec was sent to this channel. The pipe outlet level heads were checked and ranged from 5 cm to zero and below. When the head was closed to zero, the delivered discharges were very low and were simply being absorbed into the soil without surface flow. However, when sufficient head of at least 5 cm was maintained, the surface flow was faster. Hence, paddy fields were filled one after the other and losses were minimized.

It was estimated that with the assumed seepage and percolation rate of 25 mm/day on dry soil, only about one-third of the extent under a channel could be irrigated at a time.

The author then met with the farmers to explain how they could obtain the necessary water supply to meet their cropping requirements. They were shown the layout of their channel system and the associated soil texture and topography. He explained that simultaneous issues wasted water because of the sandy nature of the soil. Under such circumstances the high seepage and percolation rate did not allow the small flow to cover the area on time. Further he explained that if water issues were confined to only part of a channel at a time, by irrigating one-third of the extent, the discharge could be increased to the pipe outlets due to the increase in water head. Under these conditions, the four days then required to irrigate their fields could be reduced to 12 hours.

In response the farmers admitted that the sandy soils in their tracts wasted water when they tried simultaneous issues. However, they were concerned that unless they tried to get water to their fields at the earliest possible opportunity, they would suffer from acute shortages of water. Because of their past experience, the farmers also doubted the feasibility of releasing issues by sections. As to be expected, those farmers at the head of the channel were upset because they had grown accustomed to having an unlimited water supply to their lots. However, most of the tail-end farmers expressed interest in the possibility that they could get water for at least 12 hours or so without interference.

At the end of the meetings most of the veteran farmers were still doubtful about the venture.

Demonstration of Proposed Rotation

The farmers were subsequently invited to observe a demonstration of the proposed water issue. The demonstration area was in turnout no. 4 of field channel no. 9 with an extent of 11 ha at the tail end. The demonstration was scheduled from 7.00 a.m. to 7.00 p.m. As this was during a cultivation season with low tank water level, the demonstration had to be done carefully. Although intentions were good, if something went wrong the department could have been blamed for wasting precious water during a shortage.

In order to ensure that the pipe outlets would have sufficient heads of water, the following steps were taken: 1) the head sluice gate was opened at 4.30 a.m., 2) flows were monitored to ensure that there was sufficient head maintained at turnout no. 4 by 6.00 a.m., and 3) field staff ensured that field channel no. 4 was ready for commencement of water issues at 7.00 a.m.

About 12 allotments were to be used for the demonstration, but only a few farmers turned up to see the demonstration. Field channels ran to full supply depth to deliver 3.8 cm (1.5 inches) water. The departmental patrol laborers were stationed in the area and recorded the extents irrigated at 4-hourly intervals. The department employees recorded their observations as follows:

1. At about 4.00 p.m., 3 hours before the end of the water issue, about 30 percent of the demonstration allotments had already received water for the entire 0.8 ha. These allotments were irrigated through 10 cm diameter pipes with a head of about 15 cm.
2. At about 7.00 p.m., when issues were stopped, another 30 per cent of the allotments had received sufficient amounts of water. These lots had allotments served by 10 cm diameter pipes of 3.65 meter length, with a head of 0.5-7.6 cm.
3. The remaining 40 percent of the allotments received enough water to cover 75 percent of their area when issues were stopped. These had heads of water less than 2.5 cm.

By nightfall several farmers came to the demonstration area to see the results. Since the department employees were on the lookout, no interference took place, and the farmers could see that sufficient amounts of water had been delivered to their fields within half a day.

Since the demonstration in the FC 9 area solved most of the problems related to wastage of water and helped shorten the time spent on irrigation and supervision of issues, etc., it was considered worthwhile to try the same procedure in the rest of the rehabilitated area under FCs 1-20.

In the subsequent weekly Water Issue Board meeting, the method of issuing section by section was discussed at length. At the meeting farmers were informed that: a) all the pipe outlets would be relevelled and placed so as to maintain a head of 10 cm; b) consideration would be given to the field layout and soil conditions even though the pipe outlets had equal delivery heads; and c) the deliveries would vary if the pipes were leading into high paddy fields.

So at the subsequent water issue committee meeting, the procedures that were to be effected in order to make equitable deliveries to individual lots through the 10 cm Hume pipes were explained. All the farmers were requested to be present during the laying of pipes in their respective field channels. Gradually all the channel sections falling under each rotation were sorted out and the pipe outlet levels altered to equalize deliveries.

The next step in convincing the farmers to accept rotations on a regular basis, was a demonstration issue on a larger scale. The next demonstration issue covered the entire Unit 3 area comprising 1-20 FCS. The issue was done after summoning a meeting of the entire Unit 3 area where farmers and channel representatives were requested to keep watch over the issue to prevent any interference. At the meeting, the author pointed out the success of the earlier demonstration and asked the farmers to stick to the issue schedule. They were also told that requests for additional issues would not be encouraged by the committee.

Gates were opened and field channels to the area under demonstration were filled. The first rotation was from 7.00 a.m. to 7.00 p.m. Departmental laborers were put on watch as in the first demonstration. Issues went smoothly, and as laborers had to leave at the close of official working hours, channel representatives were asked to supervise the night issue.

Farmers' Initial Disapproval of Rotational Distribution

Initially, the farmers were unhappy with the rotational distribution method. They made several complaints during field inspection against the continuation of water issues to the other two channel sections.

The source of trouble came from the opening of field outlets in the second and the third sections soon after the department stopped patrolling. This was done by: 1) farmers who did not attend the meetings where the beneficial aspects were explained; 2) reservation cultivators who believed that once the water issues were completed for legal allottees, the issues would be stopped without regard for their own needs for water; 3) farmers who had cultivated additional lands located below their legal allotments who were experiencing water shortages; 4) farmers who were using extra water to control the growth of weeds rather than more expensive weedicides; and 5) farmers who were used to filling their paddy field with 7-8 inches of standing water.

In general, farmers distrusted water issues in part because of their past experience in the scheme, when little order prevailed. For example, farmers assumed the issues would lead to water deficiencies during the two-week period of the demonstration. Farmers doubted whether legal measures would prevent interferences. They were reluctant to accept a new method of water distribution in which they would have to use their own resources, primarily labor. They did not want to follow technical guidance which they did not trust. And individual farmers did not want to assume leadership in organizing their peers and supervising night issues, as they might be physically assaulted or lose favor within the community.

Farmers' Petition to Stop Rotations

When it became clear that rotations would be imposed whether they liked them or not, farmers took up the matter with higher officials in the government. About 140 of them signed a petition addressed to the Government Agent of the Kurunegala District, calling for an inquiry and demanding the removal of the technical staff responsible for introducing the new method. The petition pointed out that valuable rice cultivation on which the livelihood of the community depended was facing the threat of drying up due to shortage of water. Despite the considerable amount of water in the reservoir, farmers felt they were given only a limited amount of water, and an insufficient amount to irrigate their paddy lots.

In response the Government Agent sent an inquiry team to Kimbulwana Oya Irrigation Scheme to investigate the farmers' petition. The irrigation engineer-in-charge of the division was duly informed about the petition, that an inquiry team would visit the scheme, and that the officials responsible for the farmers' unrest should be present during the inquiry.

The team comprised a district land officer and a number of officers from the *Kachcheri* (office of the Government Agent responsible for the region). The team inspected the Unit 3 area (FCs 1-20). They were satisfied that adequate water had been delivered to irrigated paddy fields throughout the area apart from a couple of high sections where water could not be applied for rice cultivations.

During the inspection of the channel system, the team found that the rotational issue method would have been acceptable to the farmers had there been no interference during the programmed water issue at nightfall. What displeased the farmers most was that they were given only 12 hours of water issue rather than the three to four days' continuous issues they had received previously.

The inquiry team advised the farmers to provide better supervision and patrolling during night issues and to follow the new techniques being promoted to save water in the reservoir.

At the close of the inquiry, the team defended the author on the question of rotations for the following reasons:

1. The procedures adopted previously by farmers during cultivation, such as not using early rainfall for land preparation, led to higher than necessary demands on the water supply.
2. Irrigating the entire command area simultaneously led to reduced flow through field outlets under low heads and excessive seepage losses, and thus was clearly wasteful.

3. Filling the paddy fields with 20-23 cm of water provided no technical advantage to the crop and leached down the fertilizers.
4. Past practices were at least partly to blame for the need to rehabilitate the scheme.
5. There was clearly a need for introducing useful irrigation management techniques to safeguard the newly rehabilitated scheme and prevent it from deteriorating again.

Adoption of Water Issues

At the subsequent meeting of the Water Issue Board, channel representatives were selected in those sections where interference occurred, and patrolling was organized by the farmers.

When the rehabilitation work was completed during 1980 yala, the author provided a water issue timetable (Figure 7) for the entire extent under the scheme for each field channel. This was openly displayed in shops and supplemented by verbal communications by channel representatives. A final version of the timetable was prepared for 1980 maha, providing data on: 1) discharge in the channel section, 2) total extent under the channel, 3) extent coming under a channel under the rotational schedule, 4) time of commencement and completion of first rotation, second rotation, and third rotation, and e) closing times for main sluice.

Schedule:

Water issue rotations were prepared to facilitate timely irrigation deliveries. The rotations were thoroughly explained to the farmers, farmer leaders, and government officers and the schedules were displayed at convenient places like shops, community centers, etc.

Condition (1): Main Channel discharge remains constant from commencement of Rotation (1) to end of Rotation (3).

Condition (2): Branch Channel discharge remains constant from commencement of Rotation (1) to end of Rotation (3).

Condition (3): Distributary Channel discharge remains constant from commencement of Rotation (1) to end of Rotation (3).

Field Channel discharge is kept constant. Discharges include an estimated 20% conveyance loss.

Rotation (1): Irrigation is to tail ends, mostly for a duration of 18 hours, to overcome: a) conveyance losses due to excessive distances, b) excessive seepage losses in allotments near the main river course, c) discharge fluctuations in branch and distributary channels, d) failure in sticking to the opening times of turnout gate by patrol laborers, and e) to provide for reservations just beyond the 0.8 ha (2 ac) allotment.

Rotation (2): a) irrigation is for a duration of 12 hours to allotments situated at the middle of field channels, b) problem of reservations sometimes do not come under this issue as allotments extend closer to drainage stream boundaries, and c) conveyance losses become lesser in these sections.

Rotation (3): a) duration is for 18 hours, of which 12 hours are for the legalized allotments and 6 hours for common issue to all reservation holders at the tail, middle or head of the channel, and b) an additional 3 hour period is allowed specially to overcome deficiencies that occur during high evaporation days.

The normal sluice closure comes into effect from 3.00 to 4.00 p.m. on the third day.

Figure 7. Timetable of the water issue program.

FIELD CHANNEL No.	TOTAL AREA (ACRES)	ROTATION			1ST DAY				2ND DAY				3RD DAY			
		1	2	3	6:00 hrs	12:00	18:00	24:00	6:00	12:00	18:00	24:00	6:00	12:00	18:00 hrs	
1	06	06	-	-		0.6										
2	18	12	06	-		0.9			0.9							
3	06	06	-	-		0.6										
4	32	24	08	-		2.4			0.6			0.6	*			
5	08	08	-	-		0.8										
6	28	-	12	16					1.2			2.4				
7	04	-	04	-					0.3							
8	14	10	04	-		1.0			0.6							
8a	04	-	04	-					0.6							
9	48	24	24	-		3.0			2.25			3.3	*			
10	18	-	06	12					0.9			0.9				
11	06	-	03	03					0.3			0.3				
12	08	08	-	-		0.8			0.8							
13	12	12	-	-		1.2										
13a	13	08	05	-		0.8			0.9							
13b	08	04	04	-		0.4			0.4							
14	18	14	04	-		1.4			0.3							
15	24	-	08	16					1.2			1.2				
16	14	-	06	08					0.6			0.6				
17	08	08	-	-		0.8										
18	33	14	06	13		1.4			0.9			1.4				
19	02	-	-	02												
20	11	05	06	-		0.56			0.56			0.6				
21	-	-	-	-												
22	09	-	05	04					0.6			0.6				
23	44	20	12	12		2.4			1.2			1.2				
24	-	-	-	-												
25	14	-	07	07					0.7			0.7				
26	13	09	04	-		0.9			0.6							
27	12	-	08	04					0.6							
27a	12	-	12	-					0.4			0.4				
28	12	-	08	04					0.6			0.6				
29	24	-	16	08					1.2			1.2				
30	08	-	-	08								0.6				
31	42	20	22	-		2.0			2.0							
32	06	-	-	06								0.45				
33	26	-	12	14					1.4			1.4				
34	08	-	-	08								0.9				
35	16	07	09	-		0.6			0.6							
36	12	06	06	-		0.6			0.6							
37	30	14	14	02		1.3			1.3							
38	32	18	14	-		1.3			1.3			0.6				
39	14	06	06	02		0.6			0.6			0.3				
39a	12	06	06	-		0.6			0.6							
40	16	-	10	06					0.75			0.4				
41	34	20	08	06		2.1			0.6			0.9				
42	22	-	10	12					1.0			1.0				
43	10	-	06	04					0.6			0.6				
44	26	-	14	12					1.3			0.75				
45	24	-	16	08					1.2			1.2				
46	12	-	08	04					0.6			0.6				
47	-	-	-	-												
48	54	20	18	16		2.25			1.3			2.4				
48a	08	-	04	04					0.3			0.3				
49	10	-	06	04					0.6			0.6				
50	06	06	-	-		0.6										
BR(2)	93	20	20	53		3.0			1.5			3.6				

* 3rd Rotation to cater FC 10 & 11;

→ Denotes irrigation continued from previous rotation

Formation of Water Issue Board

In 1980 the author set up a Water Issue Board to control and oversee all aspects of water issues. The board comprised the colonization officer as chairman, one of the cultivation officers as treasurer and one farmer leader as secretary, and a number of farmer leaders, who were elected by the farmers (See Table 1).

Table 1. Composition of water issue board.

<i>Members</i>	<i>Number</i>	<i>Expected rate of attendance</i>
1) Farmer Leaders (one as Secretary)	12	— every meeting
2) Cultivation Officers (one as Treasurer)	3	— every meeting
3) Agricultural Instructor	1	— on special occasions — once a month
4) Agricultural Assistant (KVS)	2	— frequently
5) Divisional Officer, Agrarian Services	1	— on special occasions — once a month
6) Technical Assistant, Irrigation Department	1	— every meeting
7) Work Supervisor, ID	1	— every meeting
8) Patrol Laborer	1	— every meeting
9) Colonization Officer (Chairman)	1	— every meeting
10) Field Assistant to Colonization Officer	1	— every meeting

The members of the board meet every Tuesday at 09.30 a.m. The board has a number of functions. It discusses and solves farmers' difficulties about irrigation, agriculture, land disputes, and agricultural inputs. It oversees system maintenance activities such as deciding when to do maintenance work like weeding, desilting, and filling up of scoured portions in the field channel system, and fixing dates of maintenance of main and branch canal sections. It also oversees various aspects of system operation including: fixing of water issue dates, curtailing of issues on rainy days and adhering to rotational distribution of water, and determining the details of field outlet closures and gauge levels. And it undertakes seasonal planning with available data (about two months before a cultivation season).

Occasionally, the board seeks appropriate assistance from high level officials of various departments through the respective government officials, and plans special farmer committee meetings when implementing new ventures.

Under normal irrigation the board discusses any irrigation difficulties that have arisen during previous water issues related to sufficiency, wastages, breaks, or leaks, and remedial measures taken. Depending on climatic conditions and the moisture situation in various sections it determines subsequent water issue dates. Extension officers on the board explain facts about plant pests and diseases, and their control, to farmers.

During critical stages such as drought the board prepares suitable water issue timetables to suit the available resources, discusses operational problems brought about by the critical situation and possible solutions, and arranges night patrol and security measures for the headworks and the distribution system.

Water Issue Board and Kanna Meeting Decisions

When a farmer violates a decision made and legalized by a kanna meeting, he is requested to appear before the Water Issue Board. At the meeting, the prosecution party, comprising a farmer leader, an irrigation officer or patrol laborer, a colonization officer, and a cultivation officer, presents the nature of the offense, the damages incurred, and available witnesses. After the accused explains his reasons for committing the offense, the board finds him guilty or not, and if guilty, considers the penalties to be imposed on him according to kanna meeting decisions.

The majority of offenders are owners of cattle that have been allowed to stray. In these cases, the board gives the offender the option to choose the punishment according to previous kanna meeting decisions. For each animal that strayed, he can choose either to pay the sum of Rs 50.00 (about US\$ 2.27 at that time) to the Board or, fill 100 cubic feet of earth in a damaged section of a channel specified by the Irrigation Department. In most cases, farmers choose to do the earth work on channels rather than pay the fine.

When the farmer committing the offense does not agree with the decision of the committee officials and refuses to accept the punishment, the board has two options. First, it can make a formal complaint to the police station where the accused is taken into custody and the case is investigated, and the police usually makes him adhere to the kanna meeting decision and the farmer ultimately agrees to the committee's decision. Second, if the farmer still refuses, the legal officer can prosecute the farmer for violating kanna meeting decisions.

Thus, farmers refrain from violating the kanna meeting decisions as far as possible.

Procedures for Making Water Issues

At the weekly meeting it is decided whether or not to make a water issue. Usually, a water issue is made at seven-day intervals during normal weather conditions. Relevant data and available resources are discussed among the committee members: A date is fixed to commence a water issue.

The relevant data pertaining to an issue are: 1) last date of issue; 2) available moisture in the tracts — whether any rains occurred in any of the three sections, which would allow suspending an issue to that area; 3) any adverse effect on the crop when making an issue to a certain section, (this is to avoid the multiplication of pests if the extension services have advised the farmers to curtail issues); and 4) any damage caused to any part of the distribution system where discharges could not be made, whether any maintenance is necessary in the removal of silt or obstructions in a channel, whether faulty gates and regulators need to be repaired, and what remedial measures are to be taken by farmer organizations or by the department laborers or by both groups working in collaboration.

After the meeting, farmer leaders return to their respective community sectors where the farmers they represent reside. They publish notices and pass the word around on when the water issues will commence.

The farmers in turn prepare to receive their quota on the date due. They go to their allotments and prepare the different plots for various standing water levels. They bring fertilizers, weedicides, and pesticides, to be used along with an issue. They clear their field channels of any foreign matter obstructing waterways, or fill damaged sections. They join any mass maintenance work that is organized by the farmers' association.

The patrol laborers close all the turnout gates so that the channel flow is directed to the tail ends of the main channel.

Farmer Leaders

It is important to note the advantages and disadvantages of farmer participation through the use of farmer leaders in relation to the water Issue Board (see Figure 2). Some of the advantages are:

1. The farmer leaders live in the community.
2. They are supervised by the Divisional Office of the Agrarian Services and by cultivation officers.
3. They are elected from among members of the community; thus, the community gets the option to elect its own leaders.
4. The community gets proper guidance from the farmer leaders who, in turn, meet with trained government officials in various fields on new techniques and approaches to improve the standards of the people financially, socially, and culturally.
5. Farmers are satisfied that members who violate rules approved by the community are duly penalized by the committee.
6. Farmer leaders are compensated for their time in-kind, about half a bushel of unmilled rice per acre of cultivation, by the farmers they represent. This ensures that farmer leaders are responsive to the farmers they represent.

An earlier disadvantage of this system was that the villagers were not given the opportunity to elect new farmer leaders. In 1980, these farmers were elected under the Paddy Lands Act and elections were to be held once in 3 years. But farmers were not given the opportunity to elect new leaders until 1987. In mid 1987, several farmer leaders were replaced by more competent persons. At present, theoretically, if the farmers are not satisfied with their representative, they can request the Divisional Officer, Agrarian Services, to organize another election, but this has not occurred even though there have been cases when farmers were not satisfied with a leader.

ADVANCEMENT OF THE CULTIVATION CALENDER

Necessity for Advancing the Cultivation Calendar

By reviewing the rainfall tank inflow and tank spill records, the author determined that the reservoir and the irrigable area would receive rains from early October until early December. The intensity of rainfall gradually increased towards the end of October. The tank began to spill in late October and continued to spill until the second week of December. The maha heavy rains usually stopped by the first week of December and the low intensity rains continued up to end of December.

During yala the rains would begin in late March, increasing in intensity towards the end of April. However, the inflow was less than 123 hectare-meters (ha-m) of water for most of the season. As a result, the farmers' dry season crops were subjected to severe shortages of water leading to crop failures for the most disadvantaged farmers.

Hence, it was essential to work out a feasible plan to use most of the early wet season rainfall for the first cultivation. In this way the water remaining in the tank after the wet season could be used to overcome the water deficiency during the dry season cultivation.

The author prepared a simple graph using available data including: 1) tank water level tables (which were maintained daily), 2) sluice discharge tables, 3) tank spill records, and 4) rainfall data. The author also took into account the duration of the season, tank capacity (to show how the

farmers approached an incoming season), duration of land preparation, intervals, and durations of subsequent water issues, and how the season ended.

When this graph was prepared for the 1976 maha cultivation, the following important observations were made:

1. Farmers were unaware of the value of using the early maha season rains for land preparation and nursery work. They allowed a considerable quantity of the early precipitation to go waste. Although the initial rains occurred in early October, the farmers' habit was to commence land preparation some weeks later after the tank was filled, when the rains were near their peak. On inquiry it was found that the farmers planted the rice nurseries as heavy rains set in, which often washed away their seedlings. As a result of wasting the early rains, farmers had to rely on tank storage, which then reduced the water available for the following yala crop.
2. It was clear that the farmers required about 56 days to complete the land preparation, nursery work, and transplanting. The amount of water that had been issued from the tank was over 370 ha-m. In most seasons it exceeded 493 ha-m. This constituted much wastage of water when initial issues commenced from mid-November. The maha rains generally stopped during the first two weeks in December, about half way through the cropping season. By then, farmers were using valuable tank storage while the inflow to the tank was gradually receding.
3. Farmers were in the habit of receiving water once in two weeks; sluices were kept open for 10-14 days continuously to irrigate their paddy lots, and kept closed for two weeks. Considering the amount of water issued during this period in relation to the sluice discharges, about 105-148 ha-m of water was used over an extent of 559 ha. The water level works out to about 20 cm.
4. The practice of closing the sluices for 14 days during the dry months of January and February, when very high evaporation rates prevailed, subjected the crop to severe moisture stress. Moreover, the crop was at the flowering stage during mid-February when it was exposed to the drought conditions.
5. When the rainy season ended, the tank generally had about 123 ha-m of water left for yala cultivation.

Analysis of Pre-1979 Maha Cultivation

In analyzing the maha cultivations prior to 1979, the author found that farmers were compelled to begin a late cultivation for various reasons. This led to a host of problems. First, farmers often waited till the last minute to acquire seed varieties, when availability of the best seed varieties was uncertain, which meant that farmers used a mix of seed varieties. Second, farmers across the scheme tried to procure outside labor for land preparation activities simultaneously, leading to severe labor shortages. Also, at this time, most of the outside laborers were tied up in finishing their preparation for rain-fed cultivation. Third, because farmers sowed their seeds and applied fertilizers during peak rains, the rain washed away the seeds and fertilizer, which demoralized the farmers.

Normal irrigation was done following the completion of transplanting. The interval between irrigation issues was 14 days. The crops were stressed as a result of farmers trying to save some water to extend the cultivation for a few more weeks. About 148 ha-m of water was being used for each normal issue.

Farmers had to undergo the pressure of 14 days' closure and 10-14 days continuous issue. Although the extension services trained them to apply fertilizer when the water level was at a minimum and to irrigate the crop over a four-day period for efficient fertilizer use, they had no access to water for the next three weeks or so. They had to apply fertilizers along with the water during times when most of the input was washed away. Although farmers were instructed to "use

insecticides when there is standing water," they had to wait for about 18 days for the subsequent issue to apply the insecticide to their crops.

Harvesting, at the last stage of the maha cultivation, usually came between the end of March and the first two weeks of April. At this time crops were subjected to the early yala rains. As a result, a considerable percentage of the yield would drop. When the crop was reaped and threshed, the farmer had to dry it and dispose of the bulk immediately. By the time the harvest was ready for the market, harvests from other areas were already in the market, thus depressing the selling price.

All these factors affected the farmers' yields. Prior to 1979, rainy season yields varied from 2.0-3.5 t/ha.

Analysis of a Pre-1979 Yala Cultivation

Usually, yala cultivations commenced when the farmers were satisfied that there was sufficient tank storage available in the reservoir. Because they were not in the habit of saving maha storage to overcome the inflow deficiency during yala, cultivation often started as late as May.

Figure 8 shows that farmers commenced water issues on 1 April. Land preparation, nursery work, and transplanting were in progress throughout April and until 27 May. The rains and inflow to the tank ceased from the first week of May.

Farmers spent 56 days and over 444 ha-m of tank storage along with the precipitation to complete land preparation, nurseries, and transplanting. Subsequent issues were made utilizing 104 ha-m of water. A duration of 14 days lapsed from one issue to the next.

The second rotational issue was made using 97 ha-m. Realizing the deficiency of water after a lapse of 14 days, another issue was made using 68.5 ha-m. It was apparent that the farmers needed more water in this issue, but the storage did not permit this. The entire tank storage was used before the flowering stage was reached, even though water was still needed for another six weeks. The crop had to be abandoned due to lack of water.

On analysis of the 1976 yala season the author learned that the farmers were not properly informed on how to approach the yala season. Though the reservoir was almost full, they were not prepared to start the yala cultivation using that water. Traditionally, they started cultivation after the New Year festival on 13 and 14 April.

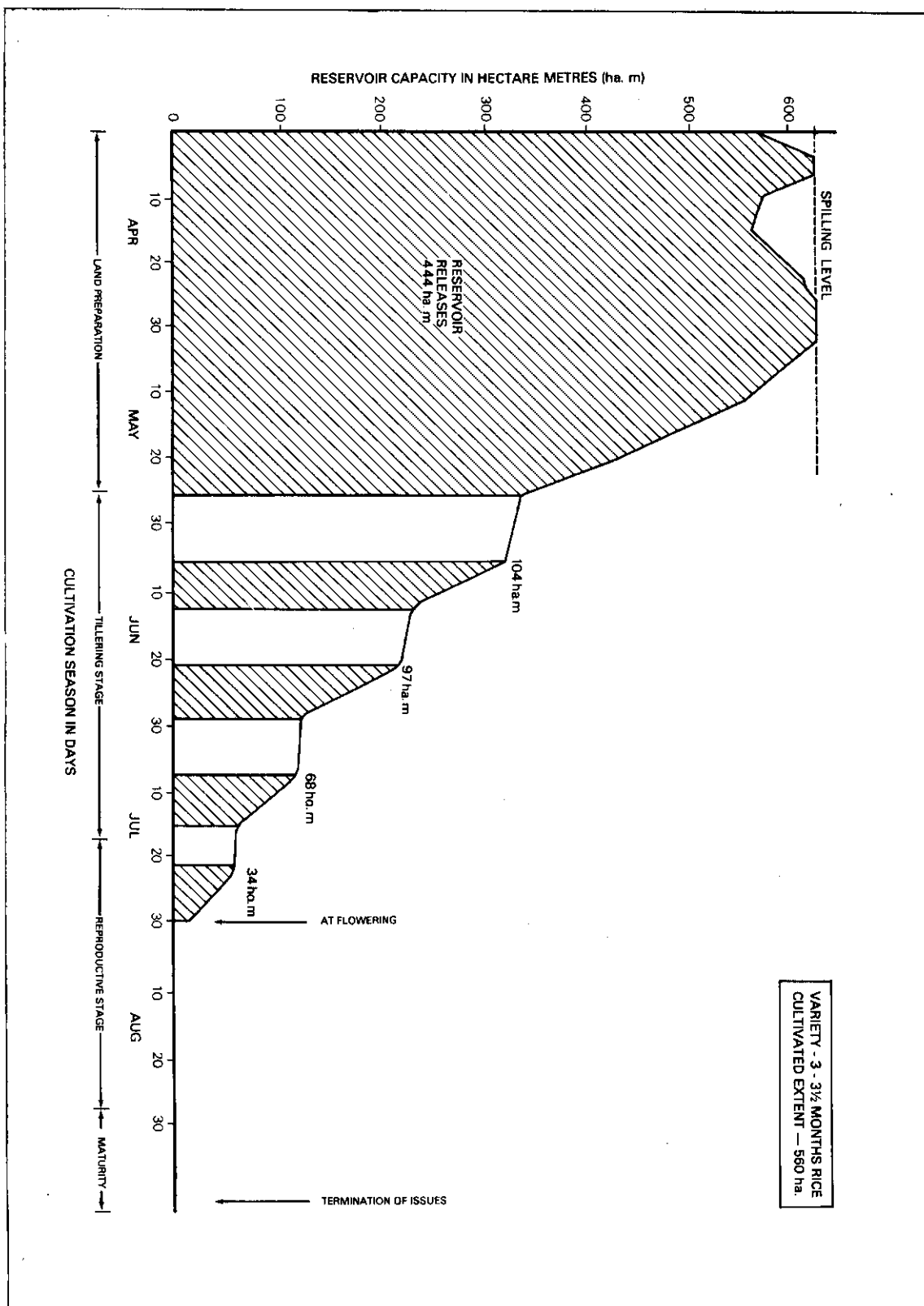
In experiencing the yala rains extensively from the third week of March, the farmers had expected the rains to continue for the better part of the yala season. They were not aware that when heavy rains set in early, a rapid decline could be forecast because yala rains usually amount to less than 457 mm.

Farmers could not obtain the seed varieties they wanted as they usually sought seeds at the last moment. They could have been asked to request the extension services to provide them with seeds and other agricultural inputs on time or they could have made their own arrangements.

Procedure in Facilitating the Advance of the Cultivation Calendar

Following the failure of yala, a series of meetings was held with the farmers under field channels 1-20. The author asked the farmers to keep an open mind regarding the ideas presented. When asked why they had to abandon most of the yala cultivation or why they had poor yields, they gave the lack of water as the principal cause. They explained that they obtained poor yields because they could not apply fertilizers and weedicides properly due to the unreliability of the water supply.

The author pointed out that they had received sufficient rainfall for land preparation early in yala.



The tank usually spilled for two to three weeks during maha, sometimes until mid-December. However, their answer to conserving the maha rain storage for the yala was to enlarge the reservoir. They did not see any other alternatives. This marked a turning point in the author's efforts to convince them to start and finish the maha cultivation earlier, thereby allowing most of the inflow into the reservoir in early December to be saved. If that was done there would be an adequate water supply to overcome the water deficiency during yala.

The farmers admitted that it was taking them too much time to do the land preparation, nursery, and transplanting work primarily because they were not prepared with the necessary inputs such as seeds. They argued that the kanna meeting was called only after there was sufficient water in the tank and that no one suggested that they use rain water in the irrigable area. They expressed the view that if the appropriate information reached them on time they could shorten the duration of land preparation.

Following this, the author and farmers discussed at length a number of problems associated with moving up the cultivation calendar:

1. *Shortening the land preparation period.* Several farmers could see the advantages in starting a season earlier. However, the decision to do so had to be made at a kanna meeting which was called only when the water level in the reservoir was satisfactory, and when Kimbulwana Oya farmers who also had rain-fed paddy lands outside the scheme could attend. These farmers normally had to complete their work in the rain-fed areas before doing their cultivation within the scheme. It was agreed that those farmers who could influence the rest would get their cultivation calendar dates advanced. These were the farmers who had allotments only under the reservoir and could not resort to earlier cultivation even if they had wanted to because the former category of farmers was more influential.
2. *Timely delivery of agricultural inputs.* The process of ordering seed varieties and fertilizers recommended during the kanna meeting required at least a month. If farmers placed their orders late, the stocks arrived late. Sometimes, in the case of limited seed varieties, farmers who placed late orders never received them. In these cases, farmers were forced to look elsewhere. When these were not available locally, they had to settle for longer maturing varieties.
3. *Labor shortage during the early rains.* In this matter the author simply requested that the farmers find remedial measures to overcome the labor problem by getting the assistance of the rain-fed cultivators who had work cattle and farm machinery by offering a reasonable amount of money, or a share of the seasonal yield.
4. *Convincing the farmer to start yala cultivation before the new year celebrations.* The new year festival in mid-April is historically one of the most celebrated events of the year. In preparation for the event, people clean and repair their homes, prepare special dishes and sweets, shop for new clothes for the family and for presents for the elders, attend family reunions, and participate in community organized games and celebrations. In addition, there are numerous religious activities. As such, it is difficult to generate enthusiasm among farmers to work on the farm during this period. Thus, despite the author's good intentions, there was considerable criticism of his attempt to move up the cultivation season to overlap with the new year.

All these factors were taken into account before the author explained the plan to advance the cultivation calendar.

1979 Maha Cultivation

Before the start of the 1979 maha, the author put forth his proposal to advance the cultivation calendar so that farmers would start land preparation at the beginning of the rains, sometime during

the first two weeks of October. Farmers were asked to complete harvesting and threshing of the yala crop as early as possible, and to feed farm animals on crop-free fields to facilitate the early manual land plowing of these fields.

The author requested the government agent through the Colonization Officer and other concerned officers to call an early maha kanna meeting. In advance of that, arrangements were made with the Agrarian Services Center to procure sufficient stocks of rice seed suitable for maha, i.e., 4-4½ month varieties. Similar arrangements were made for ordering fertilizers.

The maha rains began in early October, and the tank received reasonable inflow. By the second week of October, the department opened the sluices, and the farmers completed land preparation and nursery work. The farmers saw the benefits almost immediately. In contrast to previous seasons the peak rains of mid-October did not wash away the sown seeds and nurseries. It was not necessary to depend on water as a weedicide. Fertilizers were applied with less standing water. The farmers applied less weedicides as crops throughout the scheme were of the same age and at the same stage, which allowed weedicide applications to be carried out at the same time.

At the time of harvest in mid-March, a considerable amount of water remained in the reservoir. It then became essential to use the weekly meetings to brief the farmers on the preparations for an early 1980 yala cultivation.

1980 Yala Cultivation

During the 1980 yala season, the Water Board decided to impose a rotational water distribution in Unit 3 section (field channels 1-20). It did not plan to issue water for the Unit 2 section (field channels 21-52) because of the ongoing rehabilitation and improvements.

Prior to the kanna meeting, a majority of the farmers had acquired the necessary seed varieties and other inputs. About 25 percent of the farmers wanted to postpone the commencement of the yala season, but for no apparent reason.

The yala kanna meeting was held in mid-March. During the meeting, the farmers were given a step-by-step explanation of the preceding maha activities and a detailed account of how to plan for the coming yala. It was impressed on them that they had to comply with kanna meeting decisions so as to avoid shortages of water.

They were also reminded that their elected leaders were there to help them with their problems. The farmers who had wanted to postpone the season were persuaded to start early. The seasonal schedules and associated policies were submitted and unanimously accepted. It was decided to start yala when the tank was filled to a level of 4.6 meters.

The rainfall during the early part of yala, at the end of March, was less than in previous seasons. The minor increase of the water level in the tank was discouraging to the farmers. Hence, they had to wait until conditions improved. By the first week of May 1980, the tank level had reached 4.6 meters and, as per the decision of the Water Issue Board, the sluices were opened on 4 May, signalling the start of the yala cultivation.

The author recorded a number of achievements at the close of the season:

1. The farmers commenced work with the early rains.
2. The sluice was opened for land preparation for only 20 days: 15 days continuous issue, closed for 3 days, and again opened for 5 days.
3. The farmers actively participated in the meetings of the Water Issue Board. They openly

discussed their problems and every effort was made to arrive at solutions to their problems.

4. The farmers were more receptive to the rotational distribution of water.
5. Water to paddy lots was issued in seven-day intervals as compared with the longer intervals of previous seasons.
6. The farmers used fertilizers and agro-chemicals more effectively. Water issues were made to facilitate the better use of inputs. Despite insufficient rainfall during the middle and end of the season (apart from the early rains in April and first two weeks of May), the farmers were able to overcome the water deficiency by utilizing 1979 maha tank storage.

Organizing Farmers for a Third Crop (1982/1983)

By the end of 1981, the farmers were convinced that if they did their cultivation systematically using a properly planned calendar, they could face maha and yala with an assured irrigation supply. At that time it became apparent to the author that in years of good rainfall, a part of the yala storage at the end of the season could be saved for a third crop cultivation within the scheme.

At the beginning of the 1982 yala cultivation in mid-April, there was good water storage left from the 1981 maha. After the inflow from the May rains, the tank actually spilled from mid-May until early to mid-June. When the author plotted a hydrograph to gauge the progress of yala 1982, he determined that 60 percent, or about 370 ha-m, of tank storage would be saved by the end of the season in mid-August. Thus there was enough tank storage available to start an early maha cultivation in mid-September, a month before the maha seasonal rains usually began.

To effect an early commencement of the maha 1982/83 cultivation, the initial rice cultivation would have to receive tank water for a considerable time. To avoid excessive risk, the author carried out the following calculations before fixing the commencement date:

Available tank storage on completion of yala 1982	= 370.05 ha-m
Main channel discharge	= 1.41 cumecs

The author then determined water demand according to two scenarios, the first without, the second with, a correction factor for the effect of siltation on water conveyance.

Case I

Reduction of tank capacity/day	= 12.23 ha-m/day
--------------------------------	------------------

Approximate number of days needed to deliver volume from tank water level (TWL) 34.75 meters to 32.61 meters, a reduction in volume of 102.38 ha-m	$= \frac{370.05 - 102.38}{12.23}$
	= 21.8 days

Approximate number of days needed to deliver discharge by conveyance system until TWL = 1.21 meters, volume = 53.04 ha-m, at a rate of 0.70 cumecs	$= \frac{102.38 - 53.04}{6.11}$
	= 8 days

Maximum number of days sufficient deliveries could be made without considering evaporation loss from tank = 29.8 days

Case II

When compared to sluice discharge deliveries by means of a tank water depletion curve, more than 10 percent capacity reduction was observed due to the silting up of the tank bed.

Hence, average tank capacity reduction day = 13.45 ha-m

Evaporation and percolation loss/day over a surface area of about 161.9 ha = 0.24 — 0.37 ha-m/day

Total tank storage reduction for the first 21 days (TWL = 34.75 meters to TWL = 32.61 meters) = $21 \times (13.45 + 0.37)$
= 290.22 ha-m

Tank volume after above reduction = 370.05 — 290.22
= 79.83 ha-m

To find the number of days useful deliveries could be carried out the author carried out the following calculations.

Remaining tank volume above 31.70 meters = 79.83 — 55.50
= 24.33 ha-m

Water release rate/day with losses = 6.78 ha-m

Number of days needed to release 24.33 ha-m = $\frac{24.33}{6.78}$
= 3.59 days

Hence with losses the tank could irrigate the tract a maximum of 24.59 days.

With continuous issues for a long period, it would be possible to curtail water issue for about three days. Hence, tank delivery could be maintained during the initial cultivation work for 27.59 days from the date of commencement. It was assumed that there should be sufficient rainfall to continue the cultivation after that.

The rainfall was expected to begin by the first week of October, or around 5 October. Thus, 15 September was considered safe for commencing the 1982 maha cultivation.

With the above supporting data, the author presented the proposal for a third crop to the Water Issue Board in July 1982. The question was raised whether the farmers would be interested in raising a third cash crop assuming there was sufficient water after the yala cultivation, and sufficient time for a short-term diversified crop to mature.

In justifying the proposal, it was pointed out that at that time, the tank water level was high, about 493.40 ha-m, which was rare during most yala seasons. To complete the current yala season, the farmers needed only around 123.35 ha-m of water, which would leave about 370 ha-m. Harvesting of the yala crop could be completed by the first week of September. The maha rains were normally expected during the second week of October, or third week, at the latest. Hence, the farmers could start the maha cultivation early with the available tank storage so the expected maha rains would come by the time they used up all the water. The farmers would be able to finish the maha cultivation earlier, around the end of February. Similarly, they would also be able to start the yala cultivation in early March and finish it in early July. If there was sufficient water after yala, the farmers would be able to grow a subsidiary crop which would mature in less than 90 days.

The problems that might arise if such a plan was adopted were discussed at length. For example, all inputs — the manpower, machinery, farm animals, seed paddy, fertilizers, etc. — would have to be ready for cultivation well in advance of each season, something the farmers were not accustomed to. A conscious effort would have to be made each season to conserve enough water to last until the onset of the seasonal rains in the following season. This might mean that, due to the short intervals between seasons, farmers might be able to complete only the harvesting and would have to leave the threshing until the initial work for the next season was completed. In that case, they would have to provide watchers to look after the reaped unmilled rice in the threshing grounds.

The farmer leaders said that they would discuss the proposal further with the farmers in their respective sections, and submit their farmers' views during the next meeting of the Water Issue Board. As a whole, there was general agreement among the farmers to implement the new scheme. Several organizational meetings followed to clarify the proposal further. A draft plan was worked out which called for farmers to start maha 1982 by mid-September and yala 1983 by early March.

The matter was referred to the Government Agent and an early maha kanna meeting was called. The 1982 maha commenced on 15 September 1982 as shown in Figure 9. Farmers were able to use the tank storage until the maha rains came in the second week of October. They were able to complete the maha cultivation successfully.

With the full tank storage available at the end of maha, farmers were able to start the 1983 yala cultivation early as shown in Figure 10. They were able to complete it according to the calendar, with some water left over in the tank. With the available tank storage, they did a cash crop consisting mostly of cowpea, peas, and onions over an area of 142 ha. There were scattered rains throughout the season, and the farmers were able to complete their third crop harvest before the maha rains came.

A number of conclusions emerged from the above experiences. First, it is possible to build up farmers' confidence through long-term planning. Second, in the absence of long-term planning, it is doubtful whether such a venture could have succeeded. And third, growing a third crop (preferably, a subsidiary of less than 90 days) once in three years is possible if sufficient rainfall occurred during the yala season.

Seasonal Planning and Monitoring of Planned Issues

Use of tank water levels and depletion curves. In planning for the cropping seasons, the cultivation calendar and critical stage issues are based on the data derived from tank water level and plotted depletion curves. Tank water levels are used to indicate the quantity of water available. The tank depletion graphs are plotted with volume of water available in the tank on the Y axis and cultivation season in days on the X axis. These graphs clearly indicate: 1) the amount of water delivered on a particular day or period, 2) the inflow into the reservoir from catchment runoff and precipitation, 3) loss of water from reservoir due to seepage and evaporation, 4) cultivation calendar and crop growth stage, and 5) the rainfall data.

Figure 9. Reservoir depletion graph for 1982 maha season.

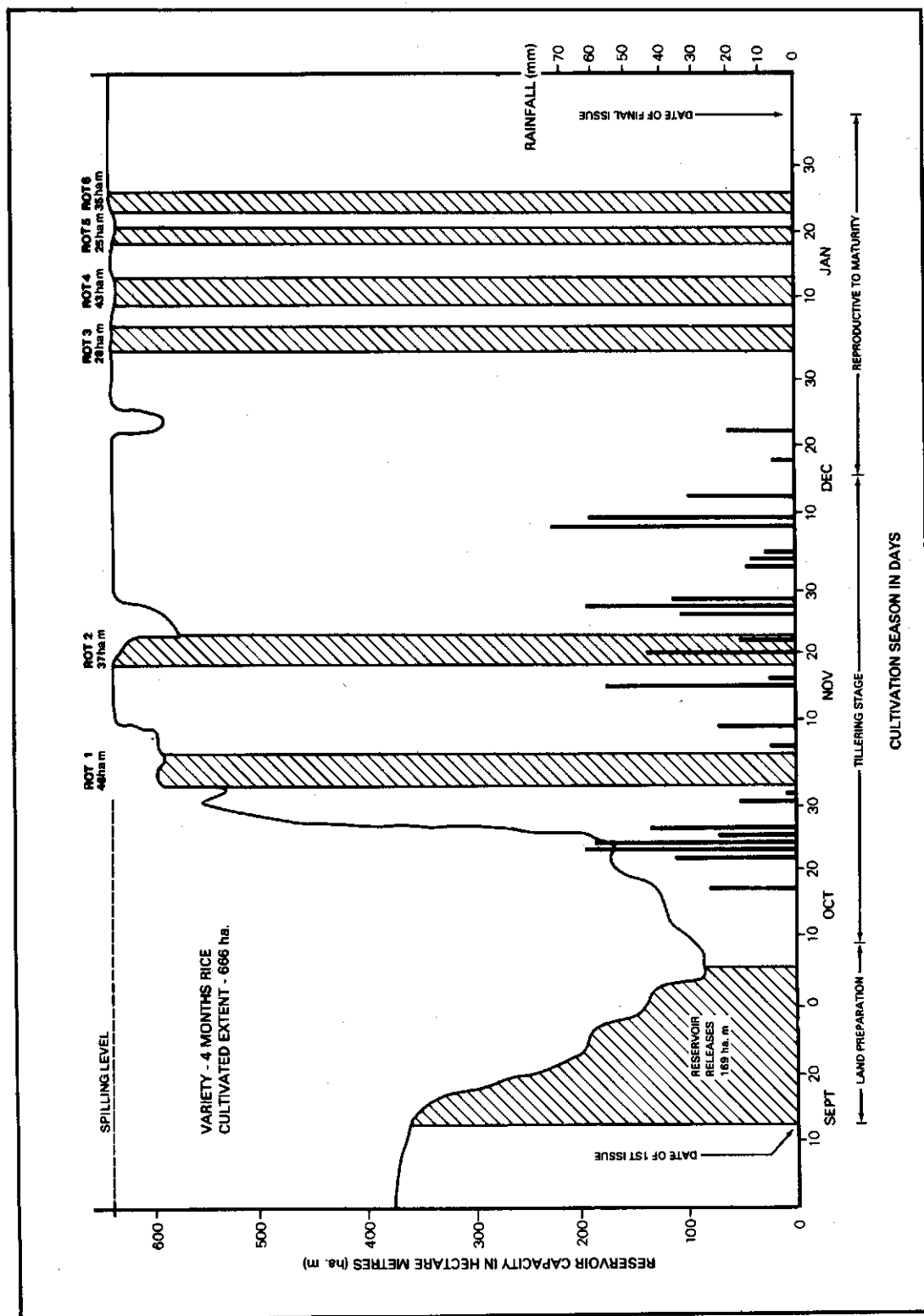
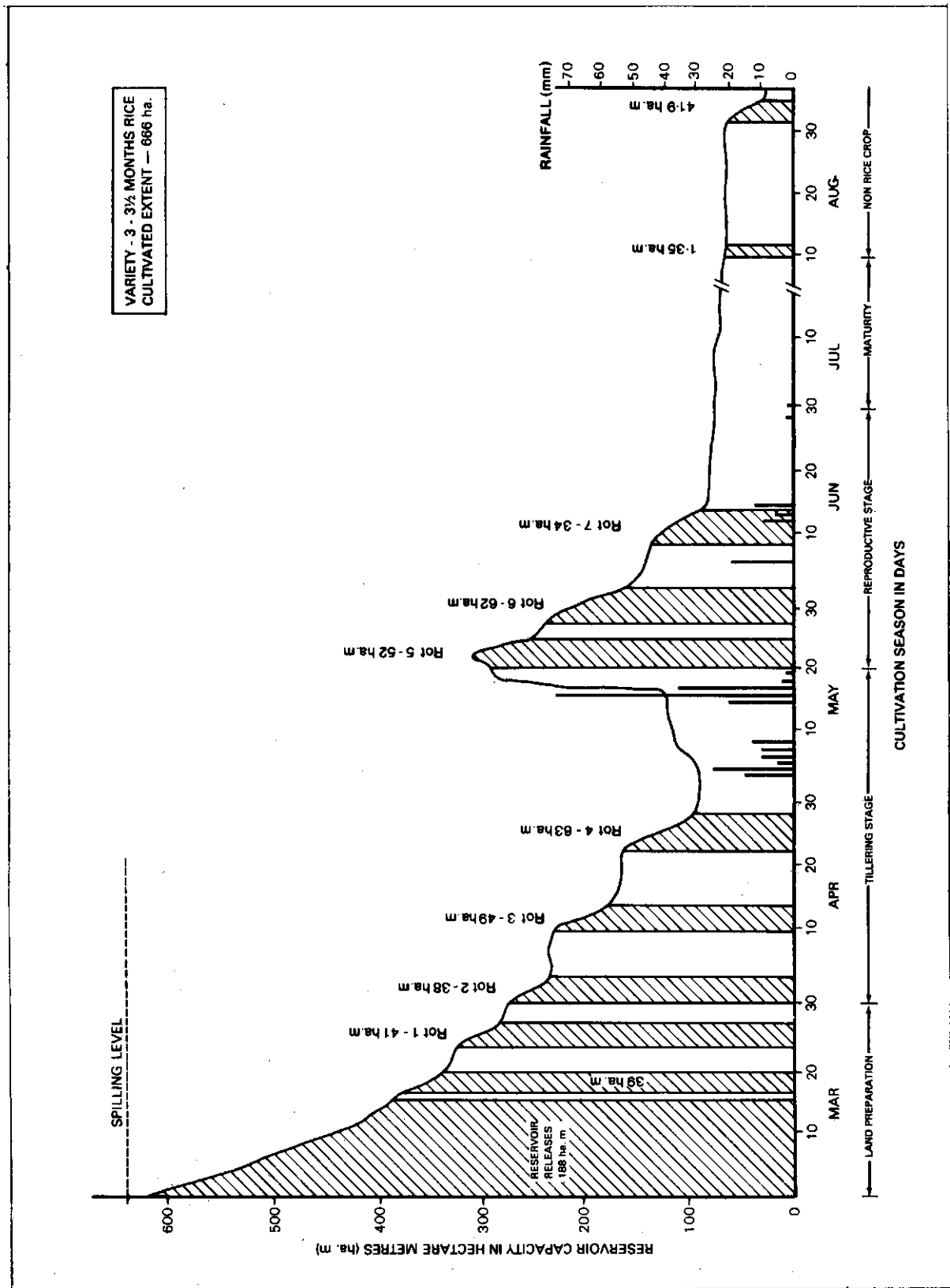


Figure 10. Reservoir depletion graph for 1983 yala season.



When a delivery is to be made it is also essential to know the head of water in the tank so that the proper opening of the sluice gate can be given to the irrigation patrol laborer.

Distributary and field channel issues. Once the desired discharge is delivered in the main channel, the flow to distributaries and field channels is made according to a schedule. Gauges are provided below the turnout structures at the beginning of a channel. Since all the channels are run at full supply depth, these gauges reflect the discharges in individual field channels.

Water deliveries are made according to a schedule prepared on a rotational distribution basis. When the full supply level is reached in a channel, the discharge is issued to an extent of about one-third of the total area under that channel at a time.

The turnout gates from the main branch and distributary channels are operated by Irrigation Department patrol laborers. The rotation within field channels is done by farmer-appointed representatives according to a timetable.

Use of available climatic data for seasonal planning. The use of available climatic data plays an important role in seasonal planning. Early in his tenure in the system, the author made a critical analysis of about 20 years of available rainfall records within the vicinity of the Kimbulwana Oya Irrigation Scheme. It was apparent from that analysis that the tank inflow had a cyclic pattern. The area experienced heavy inflow once every 10 years as in 1957, 1967, and 1977. The yala rains seemed to exhibit a similar recurrence pattern but at a rate of once in five years. This was clearly shown when tank level depletion curves were plotted from 1975 to 1983. It was therefore possible to predict an expected tank storage and rainfall.

Based on the data relevant to the recurrence of the rainfall cycle it was possible to plan the 1981 yala cultivation and to convince the farmers about the expected poor rainfall during the yala season. As a result, they: a) commenced land preparation with the residual soil moisture from maha, b) minimized the number of days for land preparation, c) reduced water supply at tillering stage so as to conserve water for critical stages of crop growth, and d) maximized possible use of rainfall for crop. Thus, farmers were able to save their crop from the adverse effects of poor rainfall, which occurred as predicted during the season.

Other seasons could be cited to prove the utility of the cyclic pattern observed. The recent 1986 yala dry spell followed the weather pattern in 1981 yala. Because farmers were informed well ahead of the drought, they commenced the 1986 maha cultivation in October with 30 percent tank storage. Water was saved during the tillering stage and used during critical crop growth stages. Despite the severe drought, about 99 per cent of the crop was saved as farmers adhered to the preset cultivation calendar.

BENEFICIAL EFFECTS OF IRRIGATION MANAGEMENT INTERVENTIONS

Savings in Farmers' Time

With the implementation of the interventions, farmers saved considerable time in land preparation. Land preparation time was reduced from a range of 45-56 days before the implementation of the new approaches to about 15-30 days. Water requirements were reduced from 503.76 ha-m to about 123.35 to 320.71 ha-m during yala as shown in Table 2. Similar reductions occurred during maha as indicated in Table 3. The duration of land preparation was reduced from a peak of 56 days before pre-season systematic planning was introduced, to 35 days in maha and 18 days in yala. Irrigation issues were reduced from 863.45 ha-m to about 167.14-320.71 ha-m. The duration and water requirement in both seasons were undoubtedly also affected by the prevailing rainfall and climatic conditions.

Table 2. Performance analysis of yala season.

Year	Duration of land preparation (days)	Total water issued			
		In ha-m	(In ac-ft)		
1971	—	—	—	<i>Before implementing new approach</i>	
1972	—	—	—		
1973	—	—	—		
1974	35	—	—		
1975	—	—	—		
1976	56	493.40	(4000)	<i>After implementing systematic distribution</i>	
1977	49	336.25	(2726)		
1978	40	503.76	(4084)		
1979	30	Implementation	217.83		(1766)
of rehabilitation work					
1980	30	147.16	(1193)		
1981	25	261.00	(2116)		
1982	15	154.19	(1250)		
1983	18	159.12	(1290)		
1984	25	123.35	(1000)		
1985	28	319.48	(2590*)		
1986	18	263.97	(2140*)		

* Unlike in previous years, there was hardly any rainfall during the initial stage of work leading to the need for more water issues.

Table 3. Performance analysis of maha season.

Year	Duration of land preparation (days)	Total water issued		
		In ha-m	(In ac-ft)	
1971	—	—	—	<i>Before</i> Implementing systematic issues
1972	—	—	—	
1973	—	—	—	
1974	65	479.83	(3890)	
1975	—	—	—	
1976	Over 76 days	863.45	(7000)	
1977	45	456.40	(3700)	
1978	45	459.72	(3727)	
1979	35	395.83	(3209)	
Implementation of rehabilitation work				<i>After</i> implementing systematic water distribution
1980	35	167.14	(1355)	
1981	30	287.16	(2328)	
1982	30	169.38	(1372)	
1983	18	168.25	(1364)	
1984	25	251.26	(2037)	
1985	27	320.71	(2600)	
1986	25	209.70	(1700)	

Equitable Distribution of Water to Farmers

With the implementation of the rotational distribution of water, individual farmers received equal amounts of water. Every effort was made to see that this important aspect was achieved. All the pipe outlets to individual allotments of 0.8 ha were positioned so as to deliver 7.62 cm standing water over the lots. The pipes used were 10 cm in diameter, the minimum head maintained was 10 cm, and the discharge rate ranged from 11.32 — 14.16 liters/sec.

Increase in Cropping Intensity and Yields

In 1983, the opportunity to carry out a third cultivation involving subsidiary crops, using water saved from yala, increased the cropping intensity to 220 percent.

As the reliability of water supply increased, yields also increased. This is seen in Table 4, which shows the results of a survey conducted by farmer leaders in different sections within the scheme. In almost all the sections there was an increase in yield, especially under the left bank channel.

Table 4. Average yields, t/ha (bu/ac)^a

		For allotments under FC 1-20	For allotments under FC 20-50	Under L.B. Channel
1977	yala maha	totally affected by drought 2.65 (53)	2.15 (43)	—
1978	yala maha	2.70 (54) 3.15 (63)	2.15 (43) 2.30 (46)	0.75 (15) 0.90 (18)
1979	yala maha	No rice cultivation — Rehabilitation work in progress 3.40 (68)	2.15 (43) 2.15 (43)	0.85 (17) 1.00 (20)
1980	yala maha	3.25 (65) 3.40 (68)	No rice cultivation — Rehabilitation work in progress 3.15 (63)	1.10 (22) 1.25 (25)
1981	yala maha	3.45 (69) 3.50 (70)	3.30 (66) 3.40 (68)	1.15 (23) 1.50 (30)
1982	yala maha	3.70 (74) 3.70 (74)	3.65 (73) 3.60 (72)	2.30 (46) 2.35 (47)
1983	yala maha	3.70 (74) 3.70 (74)	3.60 (72) 3.65 (73)	2.25 (45) 2.25 (45)
1984	yala maha	3.85 (77) 3.90 (78)	3.80 (76) 3.65 (73)	2.55 (51) 2.90 (58)
1985	yala maha	3.65 (73) 3.95 (79)	3.45 (69) 3.90 (78)	2.50 (50) 2.40 (48)
1986	yala maha	3.45 (69) 3.40 (68)	Partial drought Drought 3.35 (67) 3.30 (66)	2.35 (47) 2.20 (44)
1987	yala	Severe drought — 30% of crop saved		

^a 1 ton/ha = 20 bu/ac.

- * It is apparent that the difference in the average yield between head- and tail-end allotments gradually decreased.
- * Very poor yields in purana lands under the Left Bank Channel gradually improved.

These data clearly show that a systematic distribution of water increased the yield by ensuring a reliable and timely water supply. Fertilizer and weedicide/pesticide applications were also properly applied because of advance knowledge of the issue dates.

Increase in Agricultural Inputs to Enhance Returns to Farmers' Investments.

The data made available to Agrarian Services Centre cultivation officers and farmer representatives showed that the interventions led to a marked increase in fertilizer applications, and a direct relationship between this and increased yields.

With the reliability of the water supply, farmers were encouraged to invest in extra agricultural inputs. Basal fertilizer was applied at the transplanting stage before the occurrence of heavy precipitation during the maha season as a result of early cultivation. The second application of fertilizer was done within 10-14 days after transplanting, and the third application within 45-56 days depending on the variety of rice. Only a minimum amount of water in the fields was maintained during the applications.

. Before each fertilizer application, water was issued to the allotments. Following the third or fourth day of maha (or on the second day of yala), the standing water level was maintained at the minimum level necessary to receive the fertilizer, during which time the farmer applied it to the crop; a subsequent issue was made 7 days later so that farmers could maintain about 7 cms of standing water. The idea was to prevent leaching of fertilizer until it had been taken up by the plant.

Thus, farmers discarded the earlier practice where fertilizer was applied when there was either no water available or when water was stored to last for 10-14 days, which it rarely did.

During yala, when water issues had to be used with utmost care, farmers followed a general "once in seven day issue" rule and applied their fertilizers accordingly. Farmers were encouraged to use weedicides and pesticides as often as necessary once water issues could be controlled under the guidance of the extension services.

MAINTENANCE OF THE WHOLE SYSTEM BY FARMER ORGANIZATIONS

Initial Maintenance Work of Minor Irrigation Schemes by Farmers

Until about 1958, maintenance work in minor irrigation schemes was done by farmers under the supervision of a vel vidane. This included: desilting the tank bed every year to increase the tank storage capacity, strengthening the tank bund by removing earth from the tank bed, and dumping the excess earth on channel bunds.

At some point farmers ceased to undertake maintenance work, marking the beginning of the deterioration of most of the minor irrigation schemes. As small tanks gradually silted up, they could only hold sufficient water to irrigate the paddy fields under them on a supplementary basis. As a result, small tanks could hold water for only an additional couple of weeks after the rains had stopped; with a single issue or two, the tanks dried up. Tank bunds became scoured and where there were leaks that were not attended to, the bund broke down when the maha rains set in.

Farmers continually requested their political leaders to institute measures to improve the

deteriorating tanks. However, the state sector, hampered by limited funds, only managed to provide them with the most essential components such as sluices and spillways. As a result, farmers suffered severe shortages of water annually.

Approaches Made to Kimbulwana Farmers to Take Over Essential Maintenance Work in Field Channels

In the Kimbulwana Oya Irrigation Scheme, once the rehabilitation work was completed in 1979, it was apparent that the government could not take responsibility for maintaining the entire scheme. It then became necessary to hand over the maintenance responsibility for at least part of the system to the farmers. In order to sustain water deliveries, channels would have to maintain specified profiles and be kept free of silt, weeds, leaks, and scours. Otherwise, deliveries would quickly destroy the network because of breached or washed away sections and structures and the rehabilitated system would suffer the same fate as it had before.

The author initiated a series of meetings to organize the farmers to avoid this. Both farmers and channel representatives were made to understand that unless the channels were properly maintained, the carrying capacity of the channels would be reduced, resulting in shortages of water during the rotational issue.

In the process of these discussions, the farmers agreed to take responsibility for the maintenance of equal lengths of channel sections since they had equal allotments of 0.8 ha. To carry this out, each farmer leader divided the total length of his field channel by the number of allotment holders to determine the length of the sections that the individual farmers would be responsible to maintain.

Wherever the allotments were leased and mortgaged, the committee requested the lot-owners to maintain their channel sections when mortgagees neglected to do it. It was agreed that legal action would be directed at the lot-owners.

In subsequent years farmers had these maintenance assignments legalized in kanna meetings to help ensure their strict compliance.

Benefits of Farmer Participation in Operation and Maintenance Activities

With time, several advantages to farmer participation in maintenance activities became clear. First, farmers desilted and weeded the field channels to the satisfaction of the departmental officers. This work was carried out three times a season, ensuring unrestricted distribution of water. For every issue, sufficient water could be diverted to the field channel to irrigate the extent of rice lands under individual rotations.

Second, the maintenance work was supervised by the farmer representative who in turn supervised the rotational issues. The farmer representative was therefore in a position to notify the Water Issue Board when complete maintenance of a channel system was required, or when a larger effort was required.

Third, as farmers became aware of the importance of proper maintenance of the system, they assumed greater responsibility in ensuring that everyone cooperated in realizing this goal.

Fourth, because of the continuous maintenance work, the structures remained in a relatively stable condition. Hence, a decreasing amount of money was spent on maintenance and repair work. For the period between June 1981 and December 1985 no expenses were incurred for repairs to existing structures. Less than Rs 10,000 (about US\$ 480) was spent on providing basins and cushions which was part of the rehabilitation project. This work could not be completed during the 1979/80 rehabilitation due to the reduction of allocations from Rs 3 to 1 million.

Farmers were able to continue with their cultivations for about six seasons without interference and their capabilities improved with every season. Because of their success in maintaining field channels, the author and his superiors felt that the farmers were ready to take over the maintenance of the entire distribution system.

Organizing Farmers to Maintain the Whole Irrigation Distribution System

In 1984, farmers who received water from Sri Lanka's major irrigation systems were required to pay a nominal sum per acre cultivated. The money collected would go to an O&M fund for the systems. Each farmer had to pay Rs 247/ha (about US\$ 10 in 1984). The fee would keep increasing until it reached a level of Rs 494/ha (about US\$ 20) as decided by the Irrigation Management Division.

The imposition of the fee yielded a good opportunity to convince the farmers to take over the maintenance of the whole system. The author gave a number of reasons to the farmer representatives for doing this.

First, the money collected annually, i.e., about Rs 130,000 was not sufficient to maintain the scheme. At most, that amount would allow the department to maintain the scheme for one season, but not for two. Second, farmers were already undertaking maintenance of the field channel system which constituted about 70 percent of the whole network. Since they had begun doing this an excellent water distribution for both seasons had been realized. Third, the farmers would have to pay Rs 200 per annum for the maintenance of the main, branch, and distributary channels and headworks, less than 30 percent of the entire maintenance workload. And few of them had enough money to pay the fee.

Fourth, if the department maintained the system, it would hire new laborers who could not be depended upon to function efficiently throughout the season, or to be accountable to the farmers. Fifth, the farmers could attend to the maintenance work during off season and in between cultivation dates. Last, if the farmers would agree to undertake the maintenance of the entire system, the author would try to obtain a concession in paying the O&M fee. The author explained to the farmers that the government preferred that the beneficiaries look after the system, so that it would not continue to be a burden to the state.

Considering all the above, the farmer leaders organized a series of farmer committee meetings and explained to the farmers why it was necessary to have the maintenance work undertaken by the farmer organizations, how the work should be organized, when it should be undertaken, and what the net outcome of the whole venture would be.

Farmers were convinced that this was a useful venture and agreed to give it a try. They submitted written documents through the respective farmer organizations to the effect that they would undertake the maintenance of the whole system to the satisfaction of the Irrigation Department and the Water Issue Board in exchange for a concession in the payment of O&M fees. The documents were submitted to the Ministry and the local Government Agent.

Procedures Undertaken to Facilitate Farmers' Maintenance of the Entire Distribution System After May 1984

In distributing the work among farmers, it was decided to divide the main channel, branch channels, and distributary channels among the farmer organizations. The actual amount of work to be performed depended on the number of farmers in the organization, and the size of the channels and extent of work involved in each of the channel sections. This ensured that each farmer was given an equal share of the workload.

As with the field channel maintenance, the farmer leaders were given the responsibility of planning

and supervising the maintenance work from planning to execution. This included the following responsibilities:

1. *Programming.* Informing the Water Issue Board committees in time so that the required maintenance work could be scheduled.
2. *Planning.* Selecting dates outside of water issues and immediately after an issue when there would be stagnant water in the system, when channel beds were dry; acquiring tools such as cane baskets, pans, and wheel barrows, from the irrigation maintenance unit on time to execute the work.
3. *Organizing.* Informing all the farmers ahead of time in order to obtain their maximum participation by avoiding conflict with market days, religious holidays and activities, or other responsibilities.
4. *Execution.* Working closely with farmers to ensure efficiency and compliance with departmental requirements.

After turning over the responsibility for O&M to the farmer organizations it was possible to transfer excess government laborers to other irrigation systems. Three patrol laborers were kept on to work within the scheme while six laborers were transferred. The three laborers were given duties such as operation of radial gates, structure outlets, and flow deliveries; essential work during flood periods; custody of departmental stores, offices, and quarters; essential work on the main bund; urgent repair and maintenance work; and O&M work.

Nature of Maintenance Work

Farmer representatives organized the maintenance work in the main, branch, and distributary channels. All the farmers attended to this work which comprised weeding, desilting, and filling scours and washways. The work was carried out between 8.00 am and 12.00 noon, and in most cases, the entire channel system was brought to the required standard in a single day. The estimated value of the output was about Rs 12,000 (about US\$300) for a single maintenance program.

During 1984, the maintenance of the whole system, primarily involving silt removal, was done twice. After that, the entire channel system was maintained at least three times a year.

The left bank channel, which supplied water to about 82.96 ha, was about 3.84 km long and tended to silt heavily. The farmer organizations in the left bank channel organized mass work for four consecutive days to get the entire left bank main channel desilted and brought to the required standard. The estimated amount of work output was calculated to be about Rs. 12,000.

Gradually, maintenance of the main channel system became part of the farmers' routine work, precluding the expenditure of departmental allocations. Requests were again made to the Government Agent and Permanent Secretary to the Ministry for a concession in the payment of O&M fees by the farmers.

In 1985 the Honorable Minister, the Permanent Secretary to the Ministry, the Director of the Irrigation Department, and several high officials visited the scheme. At the meeting, a farmer leader explained how the maintenance work was being done by farmer organizations and pursued the matter of a concession in the O&M fees. The Permanent Secretary requested a full report, including how the farmers expected to execute the work and the conditions under which he could consider the request. A full report was subsequently submitted along with the suggestion that the farmers deposit their O&M fees once in the Government Agent's account, and continue to carry out the maintenance work that they started in 1984. The work would be executed without withdrawing money from the account. If money were to be withdrawn for some essential work, the deficit would be collected from

the farmers and redeposited in the Government Agent's account.

After considering the request, the Permanent Secretary to the Ministry granted permission to the farmer organizations to proceed with the maintenance work according to the request made.

By 1987 (at the time of this writing), farmers had already deposited about 50 percent of the expected total *deposit*, and the organizations continued to maintain the system. The total collection of about Rs. 68,000 deposited in an account was kept intact; farmers were able to maintain the system without withdrawing from the account funds for three years. This situation was expected to continue with the addition of accumulated interest. The interest will reduce the need for farmers' contributions, in the event of future withdrawals.

LESSONS LEARNED AND RECOMMENDATIONS

Lessons from the Various Interventions

The lessons learned can be categorized into four types: technical, organizational (farmers) role of government officials, and law and policy.

Technical. Sound technical knowledge to process monitored information from irrigation systems operation is essential in promoting innovative approaches to solve field-level irrigation problems.

Records kept of water deliveries, rainfall, and other climatic conditions as well as data related to the farming communities and cropping systems are useful in planning new and better system management by analyzing both failures and successes in the past.

Technologies can be presented in a simplified form to the farmer so that he can understand and eventually accept them as beneficial.

Following a systematic water issue timetable is advantageous to the farmers as well as to the government officials. It saves time, prevents wastage, and ensures equity.

Starting a cultivation season along with early seasonal rains helps save the crop as well as save inflow to the reservoir to overcome water deficit in the subsequent season. It is beneficial to the farmers if they are given opportunities to make use of assured, but limited, quantities of water.

Long-term planning can help organize farmers' activities so that they can face subsequent seasons with greater confidence and feel that their efforts are appreciated by the government sector.

Advancing the cultivation date with proper planning can increase cropping intensity, by increasing the number of crops per year.

Organizational (farmers). Farmer participation should be considered with utmost importance and care in the planning, designing, implementation, and maintenance of an irrigation system. The sustenance of the system depends basically on how this is viewed from the perspective of a farmer at the field level.

During the construction and rehabilitation of an irrigation system, attention to the psychological aspects of farmers should be considered as essential as the physical inputs for the sustenance of the system.

Farmers will accept guidance from a control body if they are satisfied that justice is observed and favoritism is discouraged, thereby ensuring equitable water allocations irrespective of the location of paddy allotments.

The control body should meet at least once a week to discuss relevant matters. If there are problems and conflicts the body should solve them and prevent them from accumulating.

The meeting of the Water Issue Board facilitates communication between government officers and farmers. It helps in the process of updating all concerned about such situations as availability of resources and the extent they should get involved in various aspects, or alternatives. Farmers can also plan their activities better regarding their use of labor and other agricultural inputs to produce increased yields.

The gradual participation of farmers in O&M can reach a stage where farmer beneficiaries maintain the whole distribution network, thereby reducing the financial and management burden of the irrigation agency.

Role of government officials. A government officer can increase his or her effectiveness by establishing his credibility and professionalism (tactfulness in dealing with people) and impartiality. Along with government officers a control body of an irrigation system can consist of elected farmer leaders under the supervision of agency personnel. Farmer leaders can be trained to assume leadership positions and provide impartial service to those they represent. The leaders can be guided by professionals in various departments and in the process be provided with legal backing.

Government agencies will receive less complaints regarding difficulties when there is proper coordination with farmers.

Law and policy. To sustain an irrigation system, viable policies must be adopted by the community to have legal backing to ensure compliance.

Maintenance of an irrigation system should be considered as essential, if not more so, than construction.

Farmer leaders should be compensated with salaries by farmers so that the former are made accountable for their performance.

Recommendations

1. Farmers' participation should be given due importance in the process of identifying problems, and in the planning and execution of remedial measures.
2. Farmer leaders identified in the community should receive appropriate training to enable them to:
a) settle conflicts among farmers, b) maintain impartiality in providing their services, c) be less vulnerable to political pressures, and d) gain knowledge in gathering data and the latest techniques in field-level demonstrations to get the feasibility of innovative ideas.
3. A control body consisting of government officers from various agencies, farmers leaders, and other interested parties can be formed to discuss matters relevant to the O&M of a system.
4. Adoption of policies relevant to the scheme by the control body avoid the development of disputes among farmers or disputes between farmers and the management. The control body should gain the confidence of the community assuming it maintains its objectivity and doesn't display favoritism.

The control body needs legal backing to assert its authority in prosecuting offenders who do not comply with the policies adopted by the community. It is essential that the control body be given proper guidance in its orientation, modes of obtaining data and information, communication, planning systems operations, and decision making to ensure its success. Neglecting any of the above aspects can lead to demoralization in the control body or the community, thereby

destablizing the whole operation. It is of utmost importance for those managing the scheme to make the effort of keep the farmers happy by identifying the causes and sorting out possible solutions in order to develop credibility. The impression made on the farmers plays an important role in the management of the scheme.

5. Government officers should have the following desired traits: the basic technical knowledge required to do their jobs; ability to relate the value of environmental factors (rainfall etc.) to available resources and manpower; ability and dedication to introduce physical changes in the system as well as changes in attitudes of people.
6. All possible efforts should be made to create an environment which encourages able government officers to experiment with innovative practices. Such an environment would comprise the following:
 - a) *Adequate salaries.* Most public servants are underpaid. Often, they incur expenses that exceed their available finances. Hence, there is great temptation for officers to try to earn additional income by doing cultivation during their free time or by resorting to malpractice. Better salaries will allow them to devote more time to their official duties and reduce temptation to engage in illegal activities.
 - b) *Protection from political interference.* The absence of such protection discourages government officers from pursuing new ideas or ventures for fear of losing face, or dismissal.
 - c) *Financial support.* The departments should provide field-level officers with adequate financial support and backing to carry out experiments that are deemed beneficial to the community and government.
 - d) *Legal backing.* The legal system should be made less complicated to provide support to the officers and control bodies in useful new ventures.
 - e) *Cooperation from other government agencies.* Cooperation from other government agencies plays an important role in systems management; if guidance, extension, and participation of other agencies is less than satisfactory, officers who take part in various approaches can be discouraged. Hence, sufficient training programs should be conducted for all categories of officers, from the field to ministry levels highlighting the value of their involvement and what is expected of them at each level. These programs should specifically stress those situations where the discretion of higher officers can be advantageous to those at the field level.