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ENHANCING THE MANAGEABILITY OF ROTATIONAL IRRIGATION IN INDONESIA

A Pilot Experiment in West Java

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Foreword

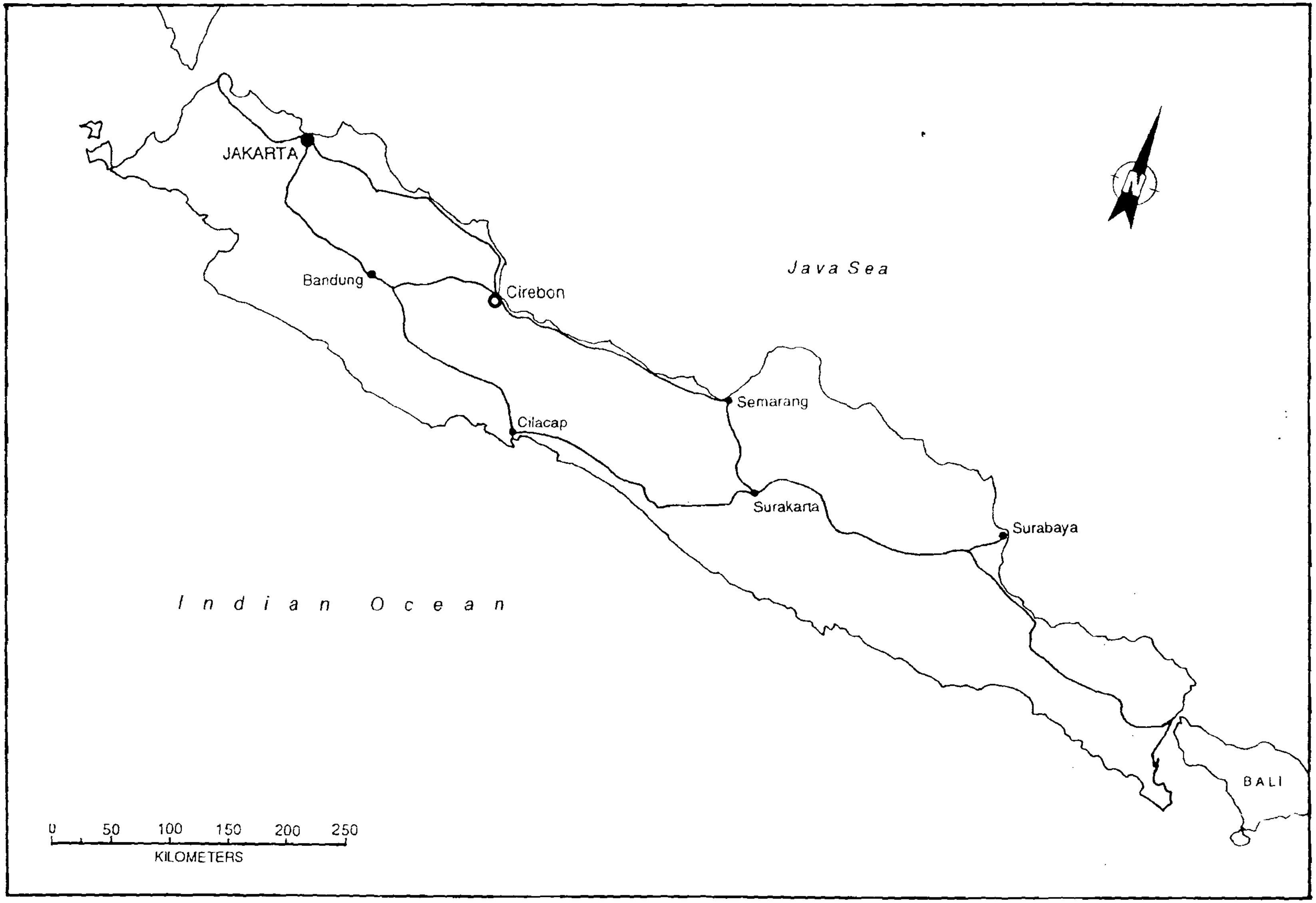
THIS STUDY ANALYZES the formation, implementation and results of a modified pilot experiment for rotational irrigation which was conducted in the 7,611-hectare Maneungteung System near Cirebon, West Java in Indonesia (Figure 1). This site was selected by IIMI in consultation with the West Java Provincial Irrigation Service and the Directorate of Irrigation I. The primary rationale for selecting this location was threefold: a) its well-diversified cropping patterns, b) its relatively well-maintained irrigation control and measurement structures, and c) its annual use of irrigation rotations in the dry season, which are required by the water scarcity related to the fact that the system's weir is the last one on the Cisanggarung River before it empties into the sea on the north coast of Java. This research was carried out during the dry seasons of 1988 and 1989.

The objectives of the study were: a) to analyze current rotation practices, b) to develop and field-test an improved rotation system, and c) to identify and test improved rotation methods which might have broader relevance in Indonesia, especially in rice-based systems undergoing crop diversification.

IIMI's mandate is to assist governments in developing nations to improve and sustain irrigation performance through management innovations. Economic and financial imperatives are currently challenging irrigation bureaucracies throughout the developing countries to transform themselves into organizations which manage resources to meet measurable objectives.

While it was recognized that eventual research and pilot experiments might lead to recommendations related to basic institutional needs or financing of operation and maintenance (O&M), it was agreed by IIMI and associates in the Government of Indonesia that the early research sponsored by IIMI in Indonesia should first explore the potential for improving irrigation management performance through modified procedures or innovations which could be adopted utilizing current O&M funding levels or only minor temporary additions to them. IIMI began its field operations in Indonesia in 1986. Such research would have diagnostic and experimental components and would be primarily field-based. This study represents the realization of these principles, demonstrating that real and immediate potential does exist for significantly improving irrigation performance through management innovations, even in agencies with relatively modest funding for O&M.

Figure 1. Location of research site in Cirebon Section, West Java, Indonesia.



Acknowledgments

THIS STUDY WAS part of a two-year Phase II research and development program, funded by the Asian Development Bank and the Ford Foundation. It consisted of two components—efficient irrigation management and small-scale system turnover of water users. A grant from the Rockefeller Foundation enabled IIMI to conduct additional activities under the component for efficient irrigation management, with particular emphasis on crop diversification and dry-season irrigation (including rotational irrigation). Additional general support in the form of IIMI office space and facilities was provided by the Government of Indonesia. Some core financing from IIMI was also utilized.

Throughout the implementation of this project full support and encouragement were provided by Ir. Soebandi Wirosoemarto, Director General of Water Resources and Ir. Koesdaryono, Special Assistant to the Minister of Public Works. Within the Directorate of Irrigation I, the following individuals provided regular support and assistance: Ir. Seonarno, Director of Irrigation I, Ir. Hamudji Waluyo and Ir. Winarno Tjiptorahadjo, both of whom served as Head of the Sub-Directorate for Operation and Maintenance during the project, and Ir. Soekarso Djunaedi, Head of Tertiary Development, and all of them made trips to IIMI field sites and offered numerous insights despite their very busy schedules.

Within the West Java Provincial Irrigation Service (PRIS), special thanks are due to Ir. Maman Gantina, Head of Water Resources and Ir. Apun Affandi, Head of O&M, in the head office in Bandung. Ir. Hadzan Sumalidjaja and Ir. Sardjono were each Head of Irrigation for the Cirebon Region (Wilayah) during part of the study. Each of them provided institutional and intellectual support for the project. It was Ir. Sardjono, while Head of Irrigation for the Cirebon Section in 1987, who first suggested to IIMI that the Maneungteung System would be a good research site.

He also helped select choice staff to be temporarily seconded to the project as collectors of field data. These included: Cecep, Nurhayanto, Taryono, Soetrisno and Affandi. These staff diligently worked many odd hours interviewing farmers and agency staff, recording discharge levels and conducting midnight inspections of the irrigation system. Ir. Kadar and Ir. Rusyan of the Cirebon Section of the PRIS provided much advice and support, as did their subsection Heads in the Maneungteung System.

IIMI research staff who worked in this project were: Ir. Busra who was graciously seconded to work with IIMI from the Directorate of Irrigation I, Ir. Supriadjo who was seconded to the project by the East Java PRIS, and Ir. Sudarmanto who supervised much of the daily activities. Ir. Adriza, assisted by Damdam and Wagiyo, provided much-valued work in data analysis. Nurlaila Solichin, Jenny Juliani and Madi were able administrative staff.

This study was conducted in collaboration with the International Rice Research Institute (IRRI), as provided for under the grant from the Rockefeller Foundation. Drs. S. Bhuiyan and T. Woodhead frequently met with staff involved in the study and made several visits to Indonesia for this purpose, offering valuable advice and insights on agronomic aspects. Dr. Fagi, Ir. Iis Syamsiah and others of the Research Centre for Food Crops at Sukamandi conducted their own agronomic research in the same area and provided perspectives useful for the purposes of this study.

Professor Suprodjo Pusposutardjo of the University of Gadjah Mada, together with several graduate students, frequently conducted research on other components of the study on Irrigation Management for Rice-Based Farming Systems, which was funded by the Rockefeller Foundation. They frequently interacted

with the IIMI and the PRIS staff involved with the study on rotational irrigation and provided considerable intellectual stimulation to the study.

It should be noted here that the Directorate of Irrigation I and the West Java Provincial Irrigation Service demonstrated real concern and interest in seeking to improve irrigation performance through pilot studies of management innovations both for his study and others in which IIMI was involved. They have been open to and supportive of this study.

Introduction

OVERVIEW

THIS PAPER REPORTS on a collaborative activity between the International Irrigation Management Institute (IIMI), the Directorate of Irrigation in the Public Works Department of the Government of Indonesia, and the West Java Provincial Irrigation Service (PRIS). The activity was a pilot experiment with modified rotational irrigation in the dry season. This was part of a broader program of action research aimed at documenting management constraints to the effective and efficient irrigation O&M in Indonesia and at testing new, low-cost procedures that are feasible to implement widely under limited budgets. Several staff of the Provincial Irrigation Service and the Directorate of Irrigation I were assigned to work on the project together with IIMI staff.

This paper describes an experiment of applying participatory management techniques to irrigation under conditions of pronounced resource scarcity: rotational water distribution during the dry season. The field experiment was carried out in the East Maneungteung Division of the 7,611-ha Maneungteung System, which is located on the north coast of West Java. At the time of the pilot experiment, the policy environment was in favor of crop diversification and expanded area under cultivation in the dry season.

Attempts were made to increase farmer involvement and base the rotation plan both on clearly defined equity objectives and on actual technical and management constraints in the system. It is hoped that this modest experiment will help facilitate an increasing management orientation in the Provincial Irrigation Services in Indonesia and will stimulate more effective experiments and innovations with the management of irrigation rotation in other settings as well. There is a pressing need to experiment with the application of management techniques to irrigation in the effort to realize whatever irrigation policy priorities governments have set for themselves, be they area expansion, agricultural intensification, crop diversification, equity, profitability at system versus farm levels and so on.

THE RATIONALE FOR ROTATIONAL IRRIGATION

There are three primary reasons why rotational irrigation is practiced: a) shortage of water to meet irrigation requirements, b) conveyance difficulties when discharges are significantly below design capacity of canals, and c) the need to avoid overirrigation of non-rice crops that are susceptible to yield reduction under conditions of excess water. This paper focuses on the first two reasons because they involve modifications to normal operating practices of rice-based irrigation systems. For agronomic reasons, rotations are usually conducted at farm or field levels and are, therefore, normally outside the operational jurisdiction of irrigation agencies.

Within the canal system, rotational irrigation is essential when total water supplies are inadequate to operate the system at or close to normal design discharge. Under normal conditions, discharges are sufficiently high so that the hydraulic relationships incorporated into the design and layout of structures and canals allow gatekeepers to maintain adequate discharges into all canals simultaneously.

However, when actual discharges fall below to about 60-70 percent of design discharge gatekeepers find it increasingly difficult to operate control structures to maintain adequate head or stream size into all canals simultaneously. For example, irrigation supervisors in the Maneungteung System use a rule of thumb that the minimum stream size acceptable into a tertiary block is 15 liters per second (l/s). If proportional division to tertiary blocks of low discharges would result in a stream size less than this minimal allocation for a tertiary offtake, the usual strategy is to rotate so that larger stream sizes hydraulically consistent with design parameters can be delivered, albeit for limited periods of time.

ROTATIONAL LEVELS

Rotations can be managed at a number of different levels in the system. The three most common levels are: rotations within tertiary blocks, rotations between tertiary blocks along secondary canals and rotations between secondary canals (or groups of tertiary blocks) along the main canal.

Rotations within tertiary blocks are common throughout Indonesia. In some systems, this is the normal operational pattern even when water is abundant. Farmers may decide it is more convenient for a few of them to receive all the discharge into the tertiary block for a limited period of time, and then pass the turn on to the next group of farmers. In this case, discharge into the tertiary block may be continuous and it is normally farmer and village leaders who initiate and manage rotations among fields.

Among the reasons for farmers to use tertiary or field-level rotations are: the time when water will be delivered to each farmer can be adjusted to the timing needs of the crop; timing can be planned and known in advance (in the same general manner as in the *warabandi* system of India and Pakistan); it minimizes the risks of overirrigation of non-rice crops; it results in stream sizes that are large enough to manage conveniently; and it allows rapid irrigation of the entire holding.

From the perspective of system managers, this type of rotational irrigation requires that the gatekeeper *(penjaga pintu air)* keep as constant a discharge as possible into the tertiary canal. Management of discharge through proper regulation of control structures remains the overriding operational rule.

Rotations between tertiary blocks require the active participation of irrigation inspectors and gatekeepers, but they should not affect main and secondary canal operations. The normal condition under which this type of rotation is required occurs when the main-level system is still being operated under continuous flow but actual water supply is in the order of 60 to 90 percent of the demand.

Under this rotational pattern, farmer and village leaders are important actors. Groups of tertiary blocks often develop plans that permit trading of water. At any given moment, some blocks will receive full discharge while others take the remainder. The length of time of allocation for each block varies depending on relative command or crop areas and the degree of overall water deficit.

In practice, this type of rotation is typically brief and transitional on a system-wide basis because it relies on having reasonably stable discharges in the main and secondary canal system. If discharges fluctuate, too much inequity will result. However, in Maneungteung this form of rotation is not uncommon in tail-end areas where water supplies are often inadequate, even though the system is being operated under continuous flow.

Once discharges drop below 60 percent of the requirement, this form becomes difficult to implement because the normal practice of rotating between adjacent pairs of tertiary blocks is no longer effective. More complex combinations of blocks are difficult to manage and the effects of conveyance losses become more complicated.

Rotations within the main and secondary canal system are the full responsibility of system managers (usually the subsection chief, *kepala ranting dinas,* or sometimes for larger systems, the section chief, *kepala cabang dinas).* Such main system rotations override the system of continuous flow and demand-based allocations, handled routinely by the irrigation inspector *(juru pengairan).*

The entire system is divided into rotational units comprising different secondary canals and groups of tertiary blocks. Tertiary blocks in each rotational unit may be scheduled to receive water simultaneously or subrotations between tertiary blocks within a rotational unit may occur between turns of the rotation units. If so, the two levels are usually planned and implemented wholly independently of each other.

The arrangement of rotational units largely determines the extent to which crop demand or area equity takes priority. If meeting crop demand is the dominant priority, then each unit should have approximately the same total water requirement. If equity is the main concern, then each unit will have roughly the same irrigable area. Of course, either criterion may be modified to account for the differential effects of conveyance losses according to distances of blocks from the top of the system.

Current operating rules in Maneungteung call for rotations at main and secondary levels once total supplies fall below 60 percent of the total system requirements. The ratio of supply to demand at system level is normally referred to as *faktor-k* in Indonesia (referred to hereafter as factor-k).

OBJECTIVES OF ROTATIONAL IRRIGATION

When available discharges are sufficient to enable water to be delivered continuously throughout the canal system it is normally possible to largely satisfy both production and equity objectives simultaneously. As discharges decrease, irrigation managers have to decide whether the shortfall is shared equally throughout the system, thereby favoring equity over maximum productivity, or to give priority to certain areas at the expense of others. Often, the outcome is by default, for want of organized agreement about clear objectives and plans. Actions tend to result in an inequitable distribution of water, with head-end areas having favorable access to water and tail-end farmers suffering most of the deficit.

The objectives of rotational irrigation are different from those of irrigation management when water is in sufficient supply to meet all or most of the crop water requirements. During rotation, the basis for water allocation which pertains under continuous flow is no longer valid and a new set of rules applies. The alternatives most often considered by system manager are:

i. *Allocation based in proportionality of crop demand,* where water is allocated in proportion to actual field-level demand, so that rotation unit sizes and locations are arranged to have similar water demands per standard unit of time, and will receive a fixed percentage of total available water; or

ii. *Allocation based on equity of proportional area,* where water is allocated in proportion to the total irrigable area (regardless of crop type), so that each farmer has equal access to scarce water supplies.

If the first alternative is adopted it is unlikely that the system will meet equity objectives because water is allocated in response to the proportion of area that has already been planted. Farmers who have been able to plant crops before water shortages occur receive a larger share of water during rotation because they have a larger share of demand. This trend is particularly clear where head-end farmers are able to plant and establish rice crops. Despite the inequity caused by this management default, this situation may be more efficient in terms of production per unit volume of water because the irrigated area is concentrated and conveyance losses will be lower than if the whole system is irrigated at a lower cropping intensity. However, this was not a policy or objective in West Java at the time of this activity.

Adopting equity as the primary objective may require greater management inputs from the irrigation agency: head-end offtakes have to be closely monitored to ensure they do not receive more than their fair share, and there will be more gates and structures to be included in the overall gate monitoring program. However, the net result ought to be that more farmers get water for at least some of their land and this has particular merit in places where farmers have limited off-farm income sources during the dry season and where water users are expected to pay some or all of the system O&M costs.

Over time, in a well-managed system that has equity as the major objective, these two alternatives will coincide: water will be allocated on the basis of the total irrigable area and farmers will adjust dry-season cropping plans to meet this overall condition.

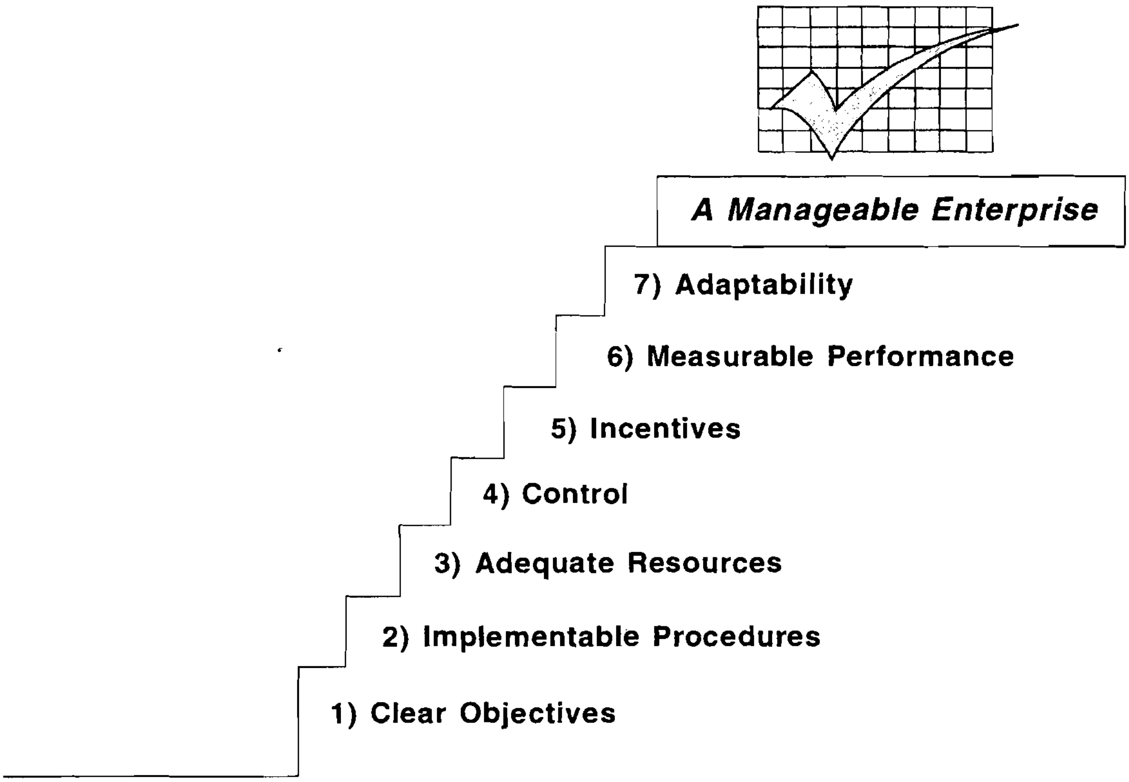
MANAGEABILITY

The pilot experiment implemented in the Maneungteung System in 1989 was an attempt to make the rotation more manageable, or in other words to be better able to achieve more clearly specified objectives. This paper uses a standard definition of management, which is, "the process of setting and achieving objectives through the acquisition and utilization of resources." We consider good management performance to be the "*efficient* and *effective* acquisition and utilization of resources to achieve organizational objectives." These principles imply that rotation irrigation must have at least seven features in order to be manageable (Figure 2). These are as follows:

Clear Objectives

They should be specific and uniformly understood by staff; there should not be dual or conflicting official versus unofficial objectives; and objectives should be altered as the situation requires. Rotational equity and efficiency objectives should be clearly specified and operationalized. Equity may be based on time, volume of water, crop water requirements, irrigated area, established allocation rights, and so on (Levine and Coward 1989).

Figure 2. Seven essential elements of a manageable enterprise.



Implementable Procedures

They should be practical and realistic to implement given resource and skill constraints. Rotational procedures should be based on the constraints of available operable gates and limited staff.

Adequate Resources

Staff, skills, technology, funds, materials, water, land and other inputs should be sufficient to accomplish the objectives at an acceptable level of efficiency. If this is not possible then the objectives or procedures should be simplified. Staff and gates could be added to permit rotation based on crop demand or else rotation could be simplified to a system which is less-resource demanding, such as rotation based on equity per unit time or area.

Control

Managers should be able to ensure that the acquisition and use of resources lead to the achievement of objectives. It should be possible to attribute management activities and results to individual managers and staff and staff should not be held accountable for outcomes which go beyond their realm of control. If the rotation requires more supervision over gates by agency staff than is feasible, then the agency can either modify the rotation so that supervision is simplified or involve farmers in supervision or do both.

Incentives

There should be positive and negative inducements for managers and staff to achieve the objectives of the organization. This might imply the need for temporary increases in staff pay or travel allowances during management intensity rotation periods.

Measurable Performance

It should be possible to document and know what the outcomes of management are and whether or not the objectives were achieved. In some cases, it may be considered sufficient to simply rely on the occurrence of farmer complaints for this feedback. In other cases, systematic monitoring of gate settings and discharges may be required.

Adaptability

Organizations must be able to change any of the above six elements as changing conditions require it —either in order to continue to achieve objectives under new conditions, to achieve them more effectively or efficiently, or to achieve new objectives pertaining to new organizational purposes. In the long term, this implies the need for annual reassessment of rotation objectives and procedures. Within seasons, this implies the capacity to adjust to different prespecified contingency plans as changing conditions require it.

For prominent sources on the above management ideas, see for example, March and Simon 1958; Drucker 1979; Richards 1986 and Anthony 1989. The need to apply principles of management to irrigation in order to achieve the increasing levels of performance is the theme of a growing literature (see Nobe and Sampath 1986; Chambers 1988; and Raby and Merrey 1989, as examples). And it was the key rationale for the establishment of the International Irrigation Management Institute in 1984. The need to involve farmers in identifying objectives, mobilizing resources and improving management control, even at distributary levels of large systems, is now widely recognized (Uphoff 1986).

Traditional Rotation in the Pilot Area

CONDITIONS IN THE MANEUNGTEUNG SYSTEM

THE EAST MANEUNGTEUNG Division constitutes 4,871 irrigable hectares of the 7,611- ha Maneungteung System (divided into two divisions, or subsystems). It is the last irrigation system diverting water from the Cikeusik Weir on the Cisanggarung River, located in the northeast corner of West Java. It is located in the Cirebon Regency.

The average annual rainfall is in the order of 1,800 mm, concentrated largely in the wet season between November and May. This rainfall, combined with high available discharge at the Cikeusik Weir, means that there is no problem, with all farmers obtaining a wet season rice crop; and in many areas farmers grow a second rice crop in the transition period between the wet and dry seasons. After July, however, rainfall is unreliable and river discharges drop quickly so that there is insufficient available water to permit full cultivation of the system, and rotation is essential.

By West Java standards the system has a high level of crop diversification, with shallot (red onion), chili, green bean, mung bean, corn and groundnut being grown in addition to rice. Many farmers who cannot grow a second rice crop will switch to non-rice *(palawija)* crops in the transition period, and there are substantial areas where a third crop can be cultivated during the peak of the dry season.

The upper end of the East Maneungteung Division (hereafter referred to as "system") is slightly undulating with no drainage problems, and is traversed by a number of small streams that are slightly incised below average ground level. The well-drained conditions and relatively easy access to water allow many farmers to obtain three crops a year. There is also intensive sugarcane cultivation in the upper and western parts of the system, where as much as 50 percent of the land may be under sugarcane at any given time. Because sugarcane production involves deep trenching of fields and leaves a lot of undercomposed organic matter in the fields following harvest, it is not normally possible to grow rice satisfactorily immediately after sugarcane. There is, therefore, a substantial area of palawija cropping in the wet season even though there is sufficient water for rice cultivation.

The lower end of the system, close to the Java Sea, is flat and poorly drained. There are periods of flooding in virtually every wet season, and this lowers rice yields and makes sugarcane cultivation very difficult. In the dry season, however, access to canal water is restricted, and many farmers rely on shallow groundwater to supplement canal irrigation supplies.

Historically, cropping intensities in the lower parts of the systems rarely exceeded 160 percent, but in recent years there has been a large increase in the area intensively cultivated to shallot and chili. The crops are grown on raised beds with the trenches used to store water between irrigation deliveries. The crops are then hand-irrigated once or twice a day using a combination of canal supplies stored in the trenches and groundwater from shallow tubewells. Some coastal areas have been converted to fish farms where there is plenty of brackish water but limited canal water supplies.

Irrigation infrastructure is in accordance with design criteria for "technical" irrigation systems in Indonesia, which means that water can be measured at every offtake, the head of most secondary canals, and at the intake at the Cikeusik Weir. The most common control structure consists of a *romijn* gate at the head of every tertiary canal, and either sliding gates or stop logs in the main or secondary canal immediately downstream of each offtake. Typically, a single structure will serve two or three tertiary offtakes.

The romijn gate is essentially a vertically adjustable broad-crested weir: this permits simultaneous control of water and measurement of discharge. Cipoletti weirs or Parshall flumes are used in larger canals or where there is insufficient head to install a romijn gate at tertiary level. This density of control and measurement infrastructure is intended to provide capacity to deliver water in precise amounts to meet crop water requirements; it also permits a wide range of different rotation options.

THE BASIS FOR ROTATIONAL IRRIGATION IN THE MANEUNGTEUNG SYSTEM

Rotation is essential because of the great differences between wet-season and dry-season conditions. Design guidelines call for tertiary canals to be able to deliver sufficient water for rice, estimated at 1.2 l/s/ha. Allowing for conveyance losses in secondary and main canals, the intake at the Cikeusik Weir and the first 8 kilometers (km) of the main canal are designed for 1.5 l/s/ha or 11.0 m^3/s. Even with this capacity, it is not possible to deliver water for land preparation for rice to all parts of the system simultaneously, so that cropping schedules are designed for a six-week stagger from head to tail of the systems.

In the dry season, available discharge in the Cisanggarung River is normally about 2,000 l/s, and may fall below 1,000 l/s in particularly dry periods. This means that actual discharge is typically only 20 percent of the design capacity of canals, and this creates severe conveyance problems. The only effective solution is to rotate between different parts of the system.

The basis for rotation in Maneungteung has traditionally been a seven-day cycle. The system is therefore divided into seven rotational units, each of which is scheduled to receive water for one day a week. In theory, different rotational arrangements exist for different levels of water shortage: one pattern when factor-k is between 0.6 and 0.4 and another when factor-k is less than 0.4.

In practice, only the more drastic rotational schedule is normally implemented because of the rapid decline in available discharge in the Cisanggarung River at the end of the wet season. Rotations normally have to be implemented late in June or early July, and are maintained until the end of the dry season at the end of October. On the first of November the entire system is closed for two weeks for annual maintenance prior to wet-season irrigation deliveries which are scheduled to start in mid-November.

Generally speaking, this type of rotational irrigation has been practiced from the time the system was rehabilitated in the 1970s as part of the wider program of upgrading irrigation systems in Java.

IRRIGATION ROTATION PRIOR TO 1989

In the early part of 1988, plans were made to make a special study of rotational Irrigation in Maneungteung. During the latter part of the 1987 dry season it was observed that there were problems at field level with rotational irrigation. Discussions with farmers showed dissatisfaction with the status quo, insofar as crops in many blocks suffered water shortages for extended periods in every dry season. Extensive lower areas of the system (and even parts of upper areas) were chronically unable to have third, or even a second crop while other areas were consistently able to plant three crops. A study of planning and implementing rotational irrigation commenced which resulted in an action-research program to modify existing practices.

Planning Rotation

The process of planning rotations requires the concurrence of people in several different agencies and villages. An initial plan is drawn up by the irrigation agency staff. This may be at subsection *(pengamat)* level of the PRIS if the subsection covers a complete irrigation system or at section level if the rotational units cover more than one subsection. In Maneungteung rotational plans are drawn up at section level because the system has three subsections.

Once the initial plan is drafted, it is presented to the meeting of the Irrigation Committee for the subdistrict *(kecamatan)* held in March. This meeting includes representatives of the Provincial Irrigation Service (PRIS), agriculture service and the local government (including village leaders). The rotational plan is discussed and approved at this time. At the meeting in 1988, the proposal drafted by the PRIS was accepted without modification by the Irrigation Committee in much the same perfunctory way as was observed in similar planning activities in Sri Lanka (Murray-Rust and Moore 1983), where agency plans are ostensibly developed "in consultation" with farmer representatives.

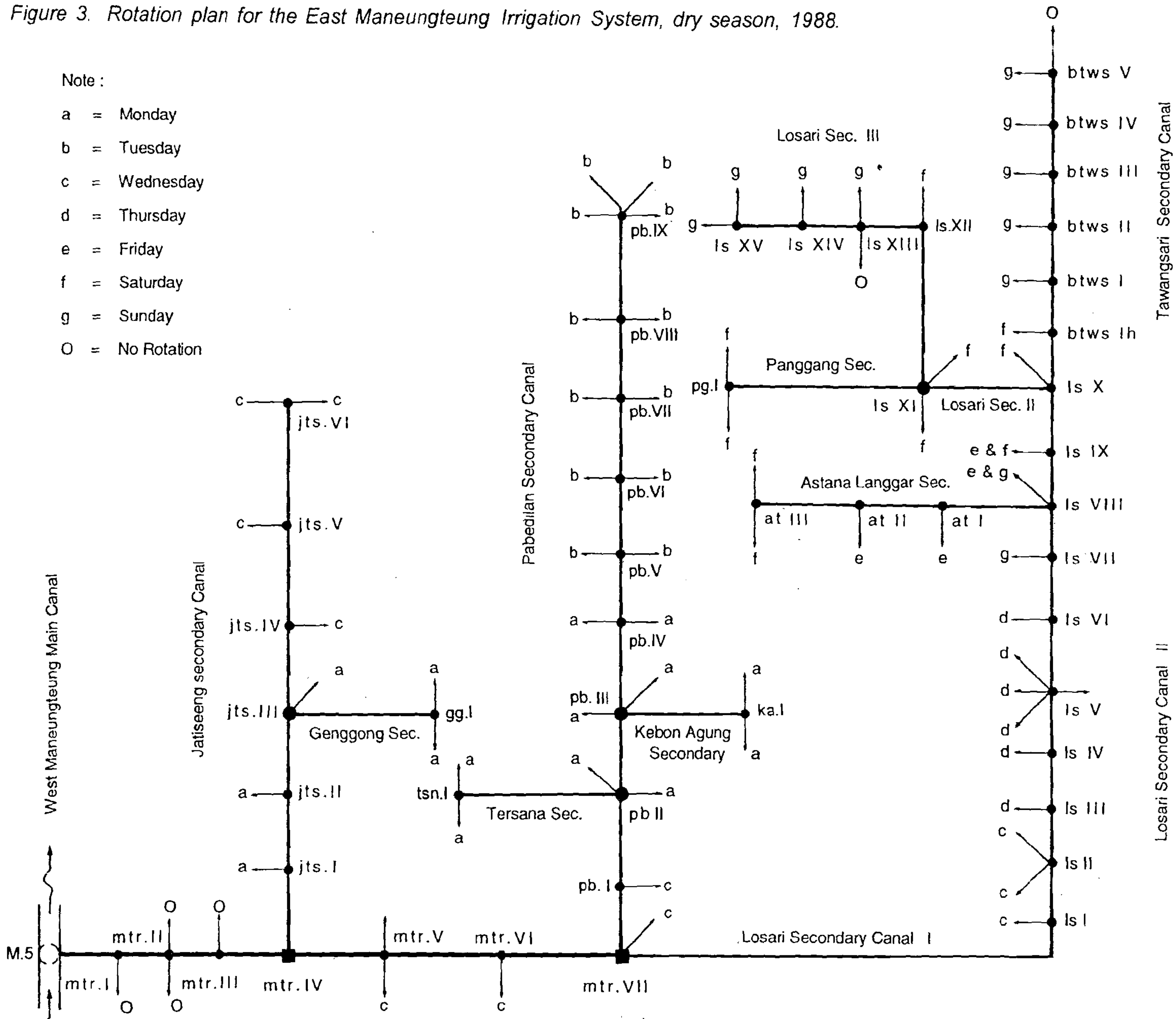
After the plan has been approved, it is intended that all village leaders and related officials will receive a copy of the plan, and will act upon it once it is decided that rotations must be implemented. This decision, which is the responsibility of the section or subsection engineer, is taken on the basis of factor-k. Each two-week period, the value of factor-k is determined by aggregating tertiary block water requirement estimates, adding in an allowance for conveyance losses in main and secondary canals, and estimating probable water availability in the river during the forthcoming two weeks.

When the system manager decides that rotations are required because factor-k has reached the critical level, the plan can be implemented unilaterally by writing to the village leaders and officials of related departments (agriculture, police, local government) of the date when rotational irrigation will commence. The time lag between sending this written communication and commencing rotations has to be about 10 days because of slow communications and the need for village leaders to inform the farmers.

Given this type of process, it is difficult to make short-term changes in the plan that accommodates different water conditions. In 1988, each rotational unit was assigned water on a specific day of the week, and there was no provision for identifying different levels of rotation for successive implementation as water supplies deteriorated.

The rotation plan covered 70 tertiary blocks. Four tertiaries at the very head of the main canal had rotation by demand (the irrigation inspector was permitted to open and close the gates at will in response to his observation of whether water was sufficient or not), 2 tertiaries along the Losari Secondary were scheduled for water 2 days a week and 67 tertiaries were scheduled to receive water once a week (Figure 3).

Figure 3. Rotation plan for the East Maneungteung Irrigation System, dry season, 1988.



Note :

a = Monday

b = Tuesday

c = Wednesday

d = Thursday

e = Friday

f = Saturday

g = Sunday

O = No Rotation

IMPLEMENTING THE 1988 ROTATION

In the 1988 dry season in the East Maneungteung System, rotational irrigation at both tertiary and secondary levels was implemented only after overall water supplied had become far lower than could be accommodated by continuous irrigation (Figure 4a). At the beginning of June, discharge in the Cisanggarung River at the weir was about 8,000 l/s, which was approximately twice the level of demand in the entire system, which was about 4,000 l/s (Figure 4b). By late June, available discharge had fallen to about 3,200 l/s and shortly after quickly passed below the system demand of about 3,000 l/s in early July. It was only at this time that the decision to implement rotations was taken, and the appropriate letters issued.

However, the discharge in the Cisanggarung River at the weir continued to drop rapidly and the system-level factor-k fell to about 0.6 by July 11 when rotations were eventually implemented. This meant that there was an extended period when the system was operated at very low discharge under continuous flow, when it was incapable of delivering discharge relationships between and along canals as designed. Tail-end areas were severely water-deficit, and considerable social tension was observed.

Field observations show that even before factor-k had reached 0.6, water was not reaching the tail end, due to poor distribution of water and the relatively large command area and length of canals to the tail end. Further, although rotations had been implemented in almost all previous dry seasons for several years, there was an additional delay between the time taken to establish the rotation plan and its actual implementation in the field.

The traditional rotation had several inequities. The inequity can be described in a number of ways:

* The number of days per week that different tertiary blocks received water during the rotational period varied from 1 to 7.

* The total irrigable area scheduled for irrigation each day of the week ranged from 403 ha on Fridays to 1,331 ha on Mondays (Figure 5a).

* The total area planted in each rotation unit ranged from 369 ha on Fridays to 1,107 ha on Mondays (Figure 5a).

* The estimated demand for water each day of the week varied greatly—although the time allocated per rotation unit was the same; this ranged from a low of 253 l/s for the Friday rotation unit to a high of 805 l/s for the Monday unit (Figure 5b).

These observations underline the difficulty of determining how to allocate scarce water. A key policy decision that has to be made is whether access to scarce water should be based on irrigable area or crop water requirements at the time the rotation is implemented. The rotations observed in 1988 allocate water primarily on the basis of actual crop water requirements at the time of rotational irrigation. Clearly, this favors head-end farmers who can get an early start to the first or second dry-season crop and who are more willing than the lower-end farmers to plant their entire fields, than are lower-end farmers. This discourages tail-end farmers from planting because they feel they will not get enough water during rotations.

Figure 4a. Discharge in the Cisanggarung River at the Cikeusik Weir during the rotation period, dry season, 1988.

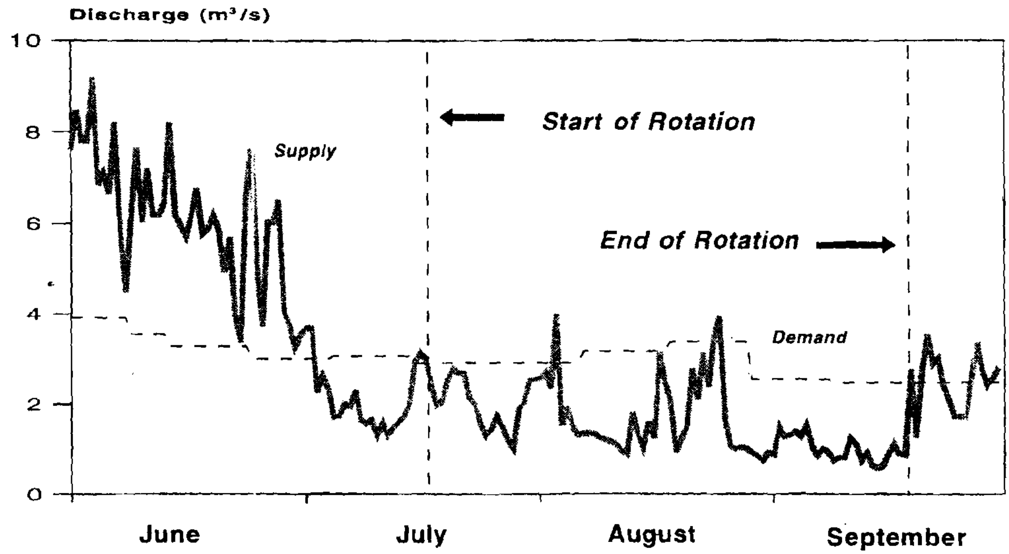


Figure 4b. Discharge in the Cisanggarung River at the Cikeusik Weir during the rotation period, dry season, 1989.

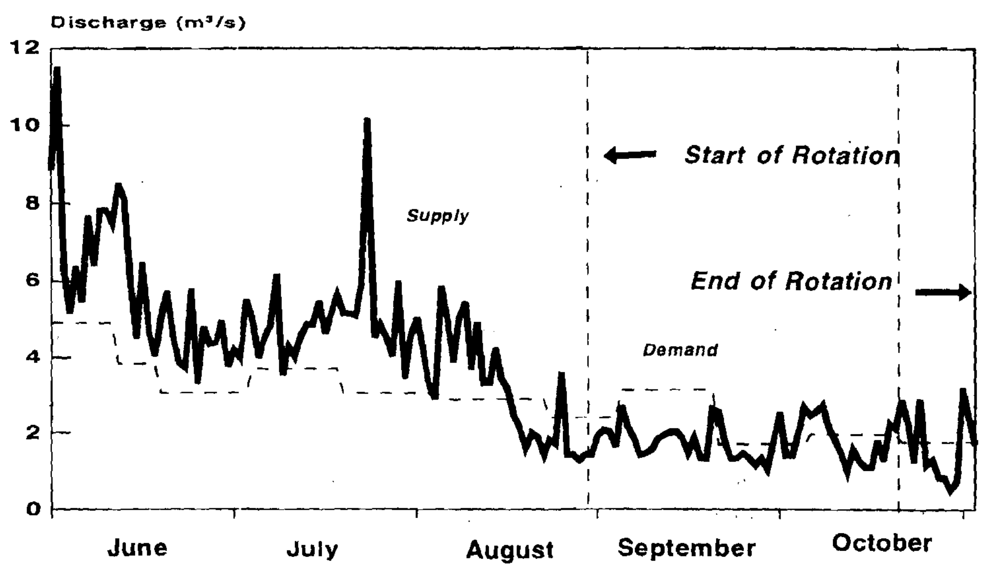


Figure 5a. Daily rotation block areas, the East Maneungteung System, West Java, dry season, 1988.

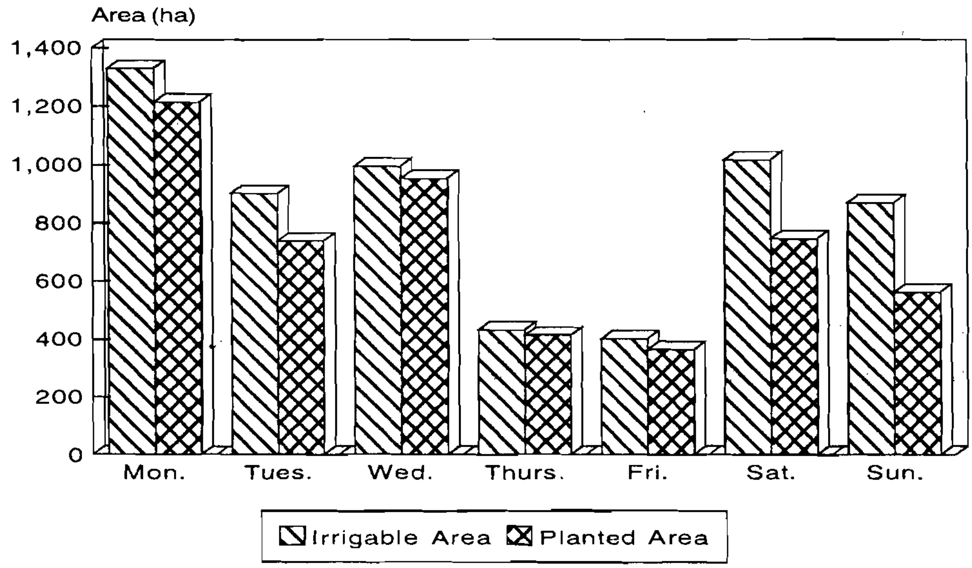
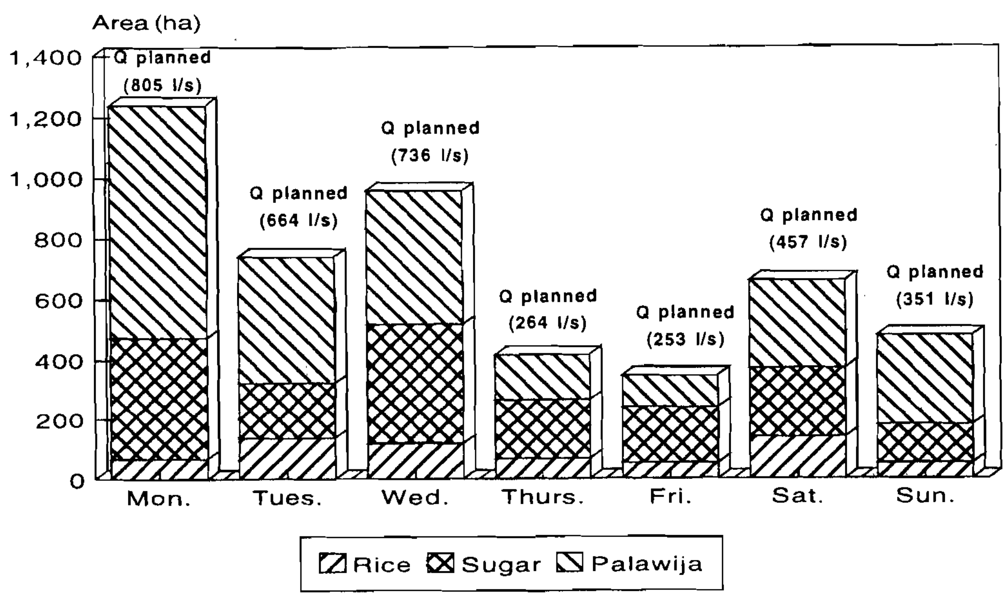


Figure 5b. Daily rotation crop areas, the East Maneungteung System, West Java, dry season, 1988.



ASSESSING THE MANAGEABILITY OF THE 1988 ROTATION

For implementation of a rotation to be practical and still provide basic access to water, it must be based upon local system design and institutional constraints rather than upon simple administrative boundaries or agricultural quotas. From repeated day-and-night inspections and interviews with the PRIS staff and farmers during the 1988 rotation in the Maneungteung System, the following observations were made:

* The rotation did not have specific objectives or criteria to justify its conventional configuration of tertiary blocks (in fact, the PRIS subsection staff did not know the basis for its origin, which preceded their time in office).

* Boundaries of rotation units were not always at locations where there was a proper control structure, making it difficult to prevent flows into areas not scheduled for irrigation.

* The length of a canal section to be filled with water on a single day ranged from 12.458 km on Wednesdays to 23.074 km on Sundays (Table 1), meaning that tertiary blocks at the tail end of long sections were highly unlikely to receive their planned share of water.

* One case was observed where the upper end of a canal was scheduled for water on one day, drained completely the next day, and then water sent to the tail section on the third day, wasting scarce water in filling and draining canal sections unnecessarily.

* There were a large number of gates, often in disparate locations, which needed to be monitored and operated (Table 2a).

* Rotation unit sizes and relative water demand were very unequal (Figures 5a and 5b) and were not in contiguous units (making control difficult).

* There was virtually no monitoring by the PRIS of where the water actually went.

* Gates were often manipulated and canals blocked by self-interested farmers.

* Staff received no bonuses and had little incentive for the intensive day-and-night tasks required to implement the rotation properly (monthly salaries of irrigation inspectors were the equivalent of about US$40.00 to US$50.00 per month, plus rice. Salaries for gatekeepers were about US$15.00, some of whom received rice as well).

* There was no adequate policing and farmers were not involved.

* There were no sanctions against water theft, which was very frequent (head-end tertiaries had a higher proportion of observations of unplanned water deliveries). The problem was more notable along Pabedilan and Jatiseeng secondary canals, but was present in other secondaries as well.

Table 1. Lengths of canals irrigated, filled or drained for implementing rotations, the East Maneungteung System, West Java.

	Irrigable area	Total canal length used	Total canal length filled	Total canal length drained
1988				
Monday	1,331	13,539	6,387	14,143
Tuesday	902	21,947	3,304	3,195
Wednesday	995	12,458	4,856	7,193
Thursday	433	12,925	3,837	3,370
Friday	403	16,380	3,455	0
Saturday	1,017	19,962	5,361	0
Sunday	870	21,295	3,854	2,521
1989				
Monday	842	9,375	3,213	14,189
Tuesday	564	10,306	4,144	3,213
Wednesday	752	15,5640	5,234	1,084
Thursday	734	14,795	3,304	2,965
Friday	576	15,282	8,130	7,643
Saturday	655	19,789	6,256	1,749
Sunday	748	20,351	4,057	2,495

Table 2a. Operational requirements for implementing rotations, the East Maneungteung System, West Java, dry season, 1988.

	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.	Sun.	Total	
Gate adjusted	15	26	15	11	8	16	24	115	
Gate closed	3	9	6	11	10	5	8	52	
Gate opened	15	1	11	9	4	8	4	52	219
Gate kept closed	5	6	0	1	11	19	18	60	279
Total gate opeation	18	10	17	20	14	13	12	104	
Total gate operation per inspector	3	5	4	5	2	3	4		
Total gates for 24-hour monitoring	20	32	15	12	19	35	42	175	
Gates for 24-hour monitoring/inspector	5	3	3	4	3	5	6		

Table 2b. Operational requirements for implementing rotations in the East Maneungteung System, West Java, dry season, 1989.

	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.	Sun.	Total	
Gate adjusted	15	3	3	16	9	11	11	68	
Gate closed	1	11	8	7	5	11	6	49	
Gate opened	9	8	11	1	11	7	2	49	166
Gate kept closed	0	0	9	15	12	15	24	75	241
Total gate operation	10	19	19	8	16	18	8	98	
Total gate operation per inspector	3	4	4	3	4	3	2		
Total gates for 24-hour monitoring	15	3	12	31	21	26	35	143	
Gates for 24-hour monitoring /inspector	2	2	4	6	6	5	6		

This is a complex situation with numerous factors leading to the observed outcome. It was reported that, in some cases, much of the unscheduled activity was due to illegal operation of gates by farmers, and in others due to tacit consent of the gatekeepers. It is difficult for the PRIS to supervise head- and middle-section gates, especially since there are a large number of days when water is scheduled to pass by these gates but not to be diverted into the tertiary blocks. Given the low pay scales, which are the same in the wet and dry seasons, there is inadequate incentive for staff to carefully implement the rotation as planned. Many of the problems noted above, however, can be explained not as failures of control alone but the result of the plan itself being inequitable and difficult to manage.

Throughout the period of the rotation all main and secondary canals and offtakes were inspected day and night on varying sample days of the week by the Study Team, to observe to what extent the rotation was being implemented as planned. Analysis of the 1988 rotational unit configuration (Table 2a) shows that of the 104 gates in the system, 52 gates had to be opened and the other 52 gates had to be closed per week. There was a weekly total of 175 gate monitorings per week, or an average of 25 gates per 24 hours which had to be monitored. There were 60 gates which had to be kept closed weekly to allow water to pass downstream. Implementation was cumbersome; control was more than a challenge.

Table 3 (upper part) shows the number of tertiary blocks and inspectors *(juru)* used per day of the 1988 rotation. This ranged from two to four inspectors' jurisdictions per day, with rotation units often cutting across such jurisdictions.

Field observations found that the plan was actually implemented 70 percent of the time observed (20% when water was scheduled and delivered, and 50% when water was not scheduled and not delivered). There were only 3 percent of cases where water was not delivered when it was planned for delivery, and 15 percent when deliveries were made but which were not scheduled. Many of the latter cases were deliveries made the day following the schedule and reflected problems with filling up long sections of canals and irrigating all tertiary blocks within a single day.

Table 3. Tertiary blocks scheduled for irrigation rotation, the East Maneungteung System, West Java.

1988

Juru	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.	Sun.	day/juru
1	4	4	4	4	4	4	4	7
2	5		6					2
3			6	7			1	3
4	10							1
5		12						1
6					4	7	1	3
7						3	9	2
Ave*. blocks/day	19	16	16	11	8	14	15	
Ave. insp**/day	3	2	3	2	2	3	4	

*Ave = Average.
**Insp = Irrigation inspectors.

1989

Juru	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.	Sun.	day/juru
1	4							1
2	11							1
3		3	3		8			3
4		4	6					2
5				12				1
6					4	6	2	3
7						7	5	2
Ave*. blocks/day	15	7	9	12	12	13	7	
Ave. insp**/day	2	2	2	1	2	2	2	

*Ave = Average.
**Insp = Irrigation inspectors.

System managers largely respond to water conditions at the head of the system rather than basing their decisions on tail-end conditions. In the case of East Maneungteung, it seems likely that unless there is substantial change in operational improvements, normal operational rules should be changed so that rotations start before factor-k has reached 0.6 to meet water deficits at the tail of the system because discharges will be less than 50 percent of design, and hydraulic conditions would have already started to deteriorate.

The Pilot Experiment

STEPS IN THE PROCESS

THE PILOT STUDY Team consisted of IIMI staff and staff assigned to the project from the Directorate of Irrigation I and from the West Java Provincial Irrigation Service (PRIS). Project review meetings between Study Team members and the irrigation agency were held at the national, provincial, section and system levels, with the frequency of meetings increasing closer to the field. It was understood that the Study Team should identify and test new procedures which did not require significant additional O&M costs or physical changes or improvements in the system. Also, the government emphasized the need to first seek improvements which could be made within the current basic administrative procedures for irrigation O&M. More basic changes should only be considered after observing the limitations of improvements which could be made within the restrictions imposed by the physical system, staff and routine funds available.

The new procedures introduced in the pilot experiment were based on management constraints found in the diagnostic stage and considerations about what improvements could be made solely through changes in the management of current resources available. In meetings between the PRIS and the Study Team, it was agreed that alterations could be made in the configuration of rotation blocks, in the timing of rotations, in the assignments to staff for supervising gate adjustments and in the role of the water users in helping determine the new rotation and supervising its implementation.

It was also agreed that the Study Team could present to PRIS a set of alternative rotation plans and describe the implications for equity, efficiency and manageability of each alternative. The PRIS, at the system (or subsection) level, would nominate one of the plans and present it for approval or revision to a meeting of all Village Agricultural Officers (VAOs, or *Kaur Ekbang*) in the system. These are the key village-level contacts for the PRIS in this area. This was decided in order to generate more commitment to the rotation plan among the farmer community. Whereas earlier the Head of the PRIS subsection would send out a letter informing village heads of the plan, it was now agreed to discuss with VAOs openly the particulars of a plan nominated by the PRIS and obtain their advice and consent, and perhaps even their assistance in implementing it.

After these principles were agreed to it was the PRIS's role to implement the new rotation, together with farmer participation in planning and supervising the rotation. It was the Study Team's role to document what happened and the results.

With the objective of developing a more equitable and manageable form of dry-season irrigation than had been used in the past, pilot testing of alternative rotational practices was carried out in the East Maneungteung System in the 1989 dry season. The steps involved in the evolution of the new rotation and pilot implementation are listed below.

1. The Study Team monitored and evaluated the previous rotation system and facilitated conveyance of views between farmers, VOAs and the PRIS staff about problems in the old rotation system. This was done through field observations and measurements, interviews and meetings.

2. The Study Team identified causes for the problems observed through data analysis, semi-structured interviews and direct field observation.

3. In discussions with various PRIS staff and farmers involved in the rotation, the Study Team helped the PRIS clarify the various potential criteria and objectives for the rotation (such as equity per actual cropped area, equity per irrigable area, practicality of implementation, and amenability of the plan to being controlled and enforced). The PRIS staff had not thought of the rotation before in terms of specific objectives or criteria.

4. The Study Team then identified a few feasible alternative rotation plans which optimized different combinations of the specified criteria.

5. Several discussions about the pilot experiment were held between the Study Team and the PRIS officials at different levels: officials of agriculture service, the local government officials and VOAs at the subsection level.

6. A meeting of the PRIS subsection chief and irrigation inspectors was held at the outset of the 1989 dry season to discuss alternative rotation options posed by the Study Team and to reach agreement on one.

7. Shortly after the above meeting to nominate the new rotation plan, the meeting was held with all the involved PRIS subsection staff, officials of agriculture service and the local government and VOAs to discuss alternative rotational plans and select one of them. In this meeting, the farmer representatives agreed, in principle, to the plan nominated by the PRIS (commenting that it would be more equitable than in the past) and made some minor suggestions about modifying it slightly. They then signed an agreement to implement it and discussed a method for involving farmer groups in policing nighttime rotation.

8. The Study Team held a planning and training meeting among the PRIS subsection staff about implementing the new rotation. It was suggested and agreed to change the rotation shifts at twelve noon instead of at midnight, as before, in order to improve awareness and enforcement of the rotations.

9. The Head of the PRIS subsection, in accordance with criteria about level of water shortage agreed with VOAs and decided when to start the rotation. It was started only in late August, due to rainy conditions which extended unusually long into August. Past main system rotations normally started in June or July, when factor K dropped below 0.4.

10. Village-level arrangements were then made to schedule rotating village night-guard groups to police the rotation schedule at night. At first, groups were assigned arbitrarily to different nights, but later the schedule was modified so that the groups which did the guarding on a given night were from the area which should be getting the water on that night.

11. The rotation was implemented as planned until the harvest of the second dry-season crop late in October.

12. The Study Team monitored implementation of the rotation through systematic day-and-night inspections along distributary canals and through interviews with farmers and agency staff. It then analyzed the data and produced and discussed reports in subsequent meetings with the PRIS and the Department of Irrigation.

ASSESSING ALTERNATIVES

Five alternative plans were developed that tried to optimize the objectives of either equalizing irrigable area of rotation units, equalizing daily demand for water, having a more simple and implementable set of gate adjustments, or having a more controllable rotation (Table 4).

Table 4. Alternative rotation plans for the East Maneungteung System, West Java, dry season, 1989.

Alternative I	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.	Sun.
Total area (ha)	776	630	658	631	686	641	849
Crop area (ha)	776	630	649	600	546	325	297
Total canal length (m)	5188	10306	13323	14795	15282	19399	20351
Location (U/M/L)*	U	U/M	M	M	M/L	L	L
Advantage	Relatively equal block sizes						
Disadvantage	Less practical to control and adjust gates						

Alternative II	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.	Sun.
Total area (ha)	776	630	555	734	686	641	325
Crop area (ha)	776	630	546	703	546	325	297
Total canal length (m)	5188	10306	15540	14795	15282	19789	20351
Location (U/M/L)*	U	U/M	M	M	L	L	L
Advantage	Gates more controllable, fairly equal block sizes						
Disadvantage	Complicated shifting between uncontiguous blocks						

Alternative III	*(Selected for pilot experiment)*						
	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.	Sun.
Total area (ha)	842	564	752	734	576	655	748
Crop area (ha)	842	564	752	734	436	333	202
Total canal length (m)	9375	10306	15540	14795	15282	19789	20351
Location (U/M/L)*	U	U/M	U/M/L	M	L	L	L
Advantage	Good inverse relationship between crop area/block and distance; block boundaries drawn where gates exist						
Disadvantage	Greater number of gates to monitor and operate than some other options						

Continued...

Alternative IV	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.	Sun.
Total area (ha)	776	630	653	734	675	655	748
Crop area (ha)	776	630	644	703	535	333	202
Total canal length (m)	5188	10306	14954	14795	15282	19789	20351
Location (U/M/L)*	U	M	M	M	L	L	L
Advantage	Improved equity of block areas over prior rotations						
Disadvantage	Less equitable than other options, difficult to manage gates						

Alternative V	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.	Sun.
Total area (ha)	917	1044	734	796	1380	1380	1961
Crop area (ha)	917	1035	703	656	512	512	1951
Total canal length (m)	10365	6002	14795	15890	23846	23846	16817
Location (U/M/L)*	U/M	M	M	L	L	L	U/M
Advantage	Block boundaries based on gate locations						
Disadvantage	Inequitable block size/distance relationship, many gates to be controlled						

Note: U = Upper part of the system, M = Medium part of the system and L = Lower part of the system

Each rotation alternative considered for the East Maneungteung System for the 1989 dry season had the following objectives:

* To develop a schedule so that the demand for water was more or less constant for six days of the week;

* To simplify the timetable so that canals were not drained and refilled more than necessary;

* To use existing control structures as effectively as possible to delimit rotation boundaries; and

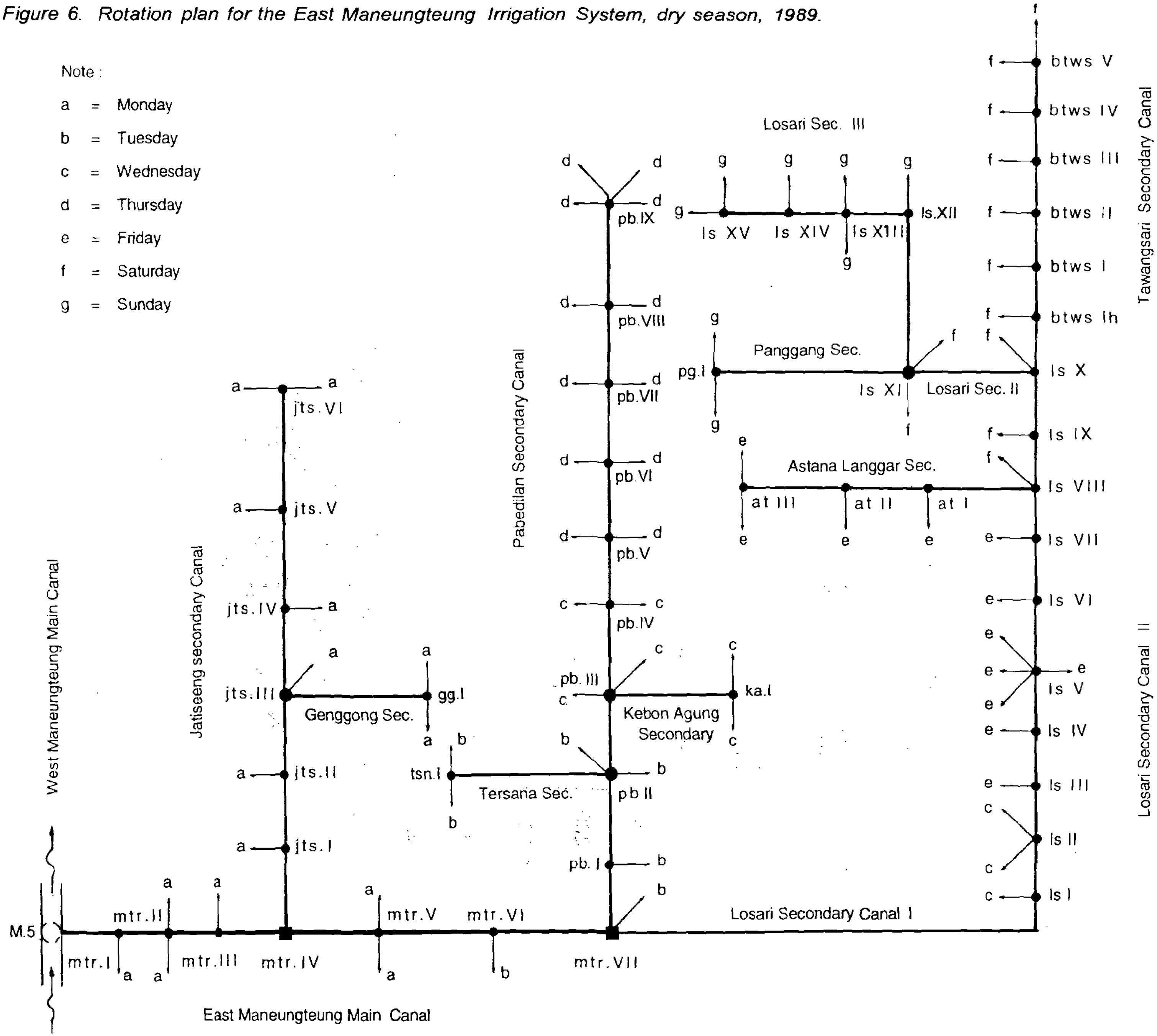
* To involve farmers and field staff as joint partners in the planning and implementation of the rotations so that everybody was satisfied that the best was made of limited water resources and that social tensions were reduced.

Each alternative was discussed among the PRIS staff and again with officials from the agriculture service, the district government and village governments. A public consensus was reached to select alternative three, on the strength of its equity and practicality for implementation. Figure 6 displays on a schematic map the new configuration of rotation units for the 1989 plan which was adopted and pilot tested.

Figure 6. Rotation plan for the East Maneungteung Irrigation System, dry season, 1989.

Note :

a = Monday
b = Tuesday
c = Wednesday
d = Thursday
e = Friday
f = Saturday
g = Sunday



This alternative had the following characteristics:

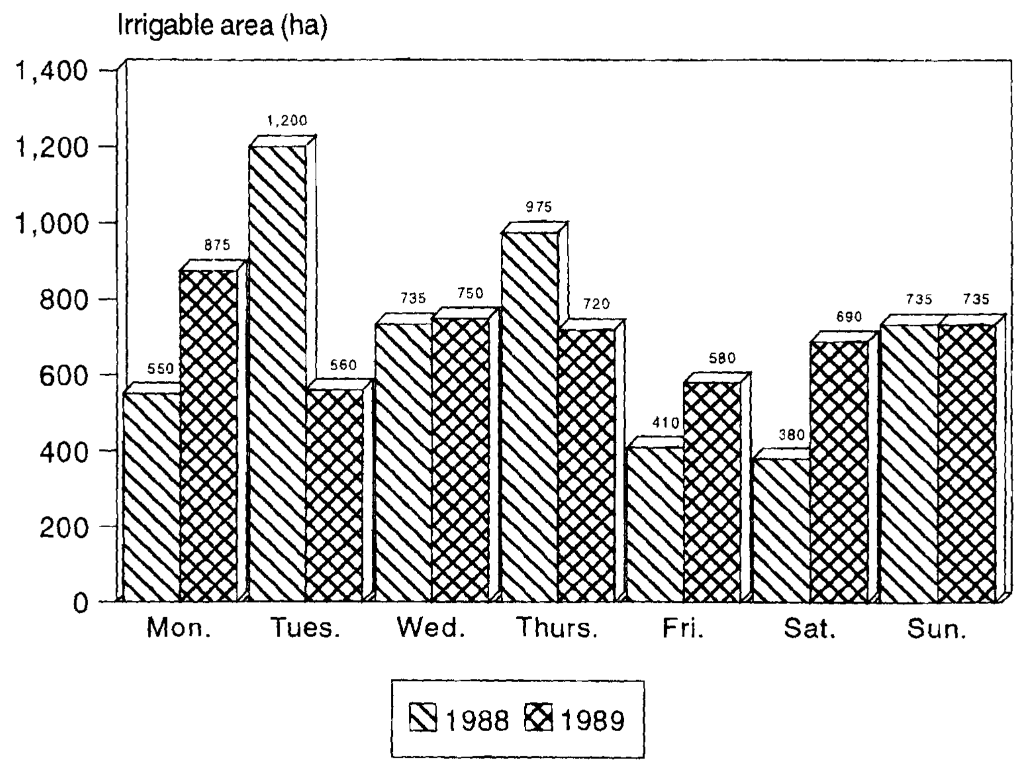
* All tertiary blocks should receive water for one day a week, with no exceptions permitted;

* Greater equity in area scheduled for irrigation each day: the daily total irrigable area varied from 56 ha on Tuesdays to 842 ha on Mondays, a ratio of only 1.49 compared to 3.30 in the 1988 pla (Figure 7);

* A reduction in the number of times when gates have to be either operated or monitored (i.e. "management inputs") from 279 in 1988 to 241 in 1981 (a 13.6% decrease) and a decrease in the number of total required gate operations (i.e., gates adjusted, closed and opened) from 219 in 1988 to 166 in 1989 (a 24% decrease, see Tables 2a, 2b and 5 and Figure 8);

* An increase in the estimated number of hours per week from 16.0 in 1988 to 17.7 in 1989, a 10.7 percent increase, when gates merely have to be monitored to ensure they remain closed (Table 5).

Figure 7. Improvement of equity in block areas between 1988 and 1989 rotations, the East Maneungteung System, West Java.



Ratio of highest to lowest area/day
1988: 3.30
1989: 1.49

Table 5. Management improvements between 1988 and 1989 rotations, the East Maneungteung System, West Java.

Irrigable area (ha):	4871
Number of gates:	114
Number of tertiary blocks:	70

1. *Management Requirements*

	1988	1989	% Change
Total management inputs	279	241	-13.6
Total required gate operations	219	166	-24.2
Gate supervisions (hours/week)	32.4	27.4	-15.4
a) Gate to be adjusted	16.4	9.7	-40.9
b) Gate to be kept closed	16.0	17.7	10.7
Downstream flow must be stopped:	10	6	-40.0
a) Using stop logs	10	0	-
b) Using sliding gates	0	6	-

2. *Equity of Rotations*

Water planned > day/week	6	0	-
Weekly inequity Index	3.3	1.49	-54.8

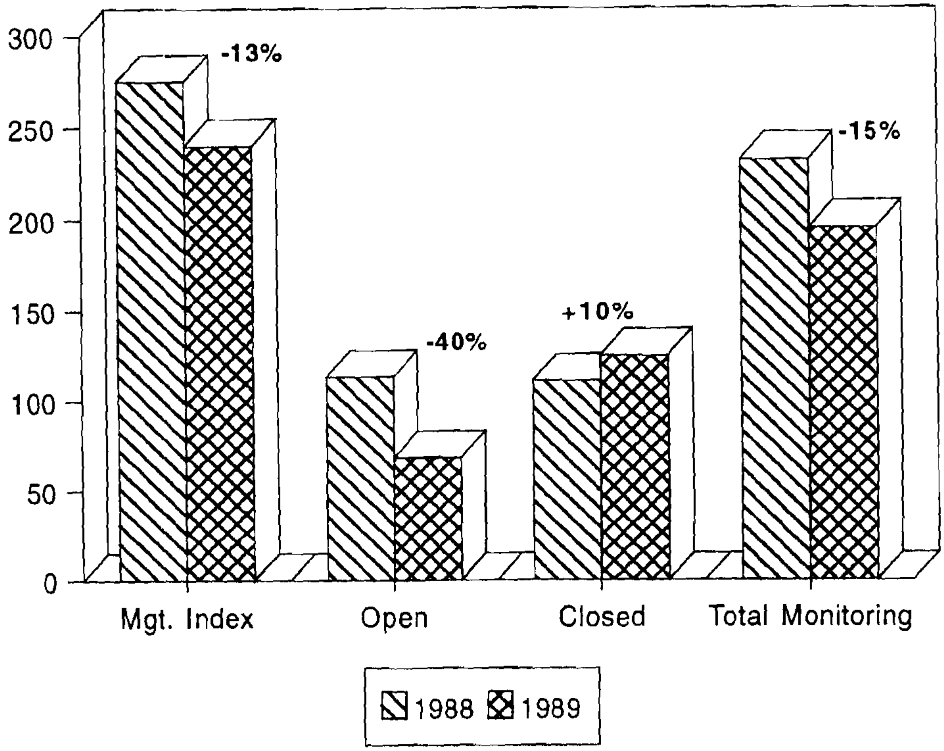
The plan was divided into two parts. The first version was intended to be implemented when factor-k was between 0.6 and 0.4. However, it was never implemented because factor-k dropped so rapidly after the rains stopped that a more substantial rotational pattern had to be implemented immediately.

One potentially adverse factor however, at least in the transition to the new rotational plan, was that the selected plan involved an increase in inequity in the actual area planted, as scheduled for irrigation on each day of the week.

Interestingly enough, this apparently negative consequence was a deliberate policy decision that was designed to overcome long-term inequity between head and tail areas of the system that has developed over several years. Farmers in the tail end have become accustomed to poor water conditions in the second dry season, and thus do not plant all their land.

It was decided by the Provincial Irrigation Service (PRIS), after discussions with the IIMI staff, that in order to encourage more equitable access to water in the long term, tail-end areas would be treated equally in terms of allocation of irrigable area *(luas baku)* rather than using past records of actual area planted. If tail-end farmers were pleased with results in 1989 and their confidence in getting more water increased, then cropping intensity in tail areas could be expected to dramatically increase in 1990.

Figure 8. Changes in management inputs between 1988 and 1989 rotations, the East Maneungteung System, West Java.



Management Index: Total gate operations
Open: Monitoring discharge
Closed: Keeping gate shut

This situation led to a deliberate inequality in the water supplied in 1989, between actual areas planted in each rotation unit. At the start of the 1989 dry season, head-end areas had been able to plant almost all their land while tail-end areas had either not received enough water or were cautious to avoid the risk of attempting high cropping intensities. Head-end areas, scheduled to receive water between Monday and Thursday had cropping intensities in August 1989 that averaged 97.7 percent (100% on Mondays and Tuesdays), while tail-end areas with water scheduled for delivery on Saturday and Sunday had cropping intensities of only 50.8 percent and 27.0 percent, respectively. By giving tail-end areas an equal share of water while they had lower-cropped areas compensated for their distance and previous poor experiences with water deliveries in the dry season.

ASSESSING THE MANAGEABILITY OF THE PILOT ROTATION

We now return to the seven aspects of manageability referred to under *Manageability* in Chapter 1. We will apply them to our assessment of the rotational management pilot experiment.

How Clear Are the Objectives?

Prior to the pilot experiment, the Head of the PRIS subsection was unaware of the criteria used to establish the earlier rotation. It was clear to him and the other PRIS staff and farmer representatives that the old approach had many flaws, including its inequity, impracticality and difficulty of control. In the discussions about results of monitoring the 1988 rotation and alternative plans, the criteria for selecting a new rotation were identified and clarified, namely that a new rotation should be based on: equity for rotation unit areas (not cropped area or real demand); the rotation should be practical to implement; and the rotational unit sizes should be inversely proportional to distance from the headworks. (Figure 7)

How Implementable Are the Procedures?

The new rotation, which was identified by the Study Team and selected by the PRIS, was substantially easier to implement—in terms of a more efficient and small configuration of gates to be monitored and adjusted. Also boundaries between the rotation units were placed where there were adjustable gates (Figure 6 and Table 4) and, because of the discussions and preparations which were made in advance, it was possible to implement the 1989 rotation much more quickly than in 1988, after discharge levels dropped off. Figures 4a and 4b show that the rotation was not started in 1988 until two weeks after system-level supply dropped below demand, while in 1989 this was narrowed to less than one week.

How Adequate Are the Resources?

Given the smaller amount of gate adjustments and monitoring needed under the new rotation, together with the mobilizing of farmers to help in policing the rotation at night, the labor resources were judged to be adequate to the tasks involved. Inspectors generally lived near their areas of work and had, at least, bicycles for transport, although nighttime use of bicycles to tour the system was considered somewhat dangerous, if done alone.

How Controllable Is the Process?

Realigning rotation unit boundaries according to locations where there were adjustable gates, switching deliveries between rotational units at midday instead of at midnight and involving farmer rotation unit representatives in nighttime policing substantially helped to make the rotation more controllable by the PRIS managers. Farmer night-watch groups were observed to be functioning on most night inspections. However, partly due to the inadequate incentives for staff, nighttime field work by the PRIS staff was probably not as intensive as was apparently needed (judging from the illegal irrigation issues which still continued in 1989, although at lower levels than before). Some farmer guard teams complained of a) not being able to contact PRIS staff at their homes at night in order to correct unofficial diversions, or b) having the diversions return to their illegal positions after they had been corrected earlier in the night. There were some accounts of complicity between farmers and the low-level PRIS staff in some of the unplanned water deliveries.

Table 6 shows that, in 1988, 30 percent of the observed arrangements during the rotation period was not in accordance with the official plan. In 1989, only 13 percent was not in accordance with the plan. Although unofficial issues were still frequently observed, they were not as frequent as in 1988, suggesting that an improvement in control was achieved.

Figure 9 displays data for each inspection through the rotation period of discharge, the relation of supply to demand for the East Maneungteung System and the number of observed unscheduled or illegal irrigation issues per inspection. The Delivery Performance Ratio (DPR) is the ratio of actual discharge delivered (supply) to planned delivery (i.e., irrigation demand). In 1989, there was a tendency for more unofficial issues to be made when the water discharge increased (apparently because the opportunity for doing it and the effective impact of these actions are magnified when more water is available).

The correlation R^2 between the number of unofficial deliveries and discharge during the 1989 rotation was 0.30. In 1988, the level of unofficial deliveries was relatively haphazard and not correlated with variations in water supply ($R^2 = 0.02$). In 1989, unofficial deliveries were concentrated in a few high discharge periods. Sometimes, given rotation units are not able to or willing to absorb all of the water entering the unit when occasional high discharges unexpectedly and briefly enter the system during the rotation period. In these cases, unscheduled allocations to other units must be made to disperse the water.

Figure 10 shows that unscheduled water deliveries under the old rotation were more spatially dispersed among rotation units, than was the case under the new rotation, where most of the unplanned activity occurred in the Monday, Tuesday and Friday units. The Monday and Tuesday units are in the upper end of the system and have been accustomed to receiving more adequate water supplies. The new rotation based on greater equity of unit sizes decreased the proportion of water scheduled for these areas.

Hence, the frequency of unplanned deliveries to these areas was partly a response to their higher expectation and a reaction to the new plan. Also the Friday unit is an area of considerable production of high value shallots, much of which is rented to large-scale operators, who tend to have resources to manipulate water allocation. Some of this area is irrigated from a stream supplied via a drain in the Monday unit.

How Accountable Are the Staff?

The existence of a formal meeting and signed agreement about the rotation between the PRIS and the village agriculture officials was an important factor in strengthening a general sense of accountability to the plan. The meeting enabled the PRIS subsection to discuss the rotation directly with village representatives, which helped override more vested interest. The nighttime rotation guard groups (usually consisting of four or five farmers who went around together) usually sought out the irrigation inspector when an illegal issue or closure was observed. This helped make the PRIS staff somewhat more accountable to the water users, although there were reports that, often, the groups could not locate inspectors or the disturbances often reoccurred later in the night, even after being corrected by the PRIS staff. Flags were placed at the head of secondaries to designate the location of the rotation turn on a given day, thereby helping clarify implementation and making violations more discernable.

The PRIS accepted a suggestion that jurisdictional boundaries of inspectors should be realigned on the basis of the new rotational arrangement and locations of gates with measurement devices. This would no doubt help the inspectors to be more accountable for flow going into and out of their areas. However, apparently more field supervision of water deliveries and activities of inspectors is needed by superiors.

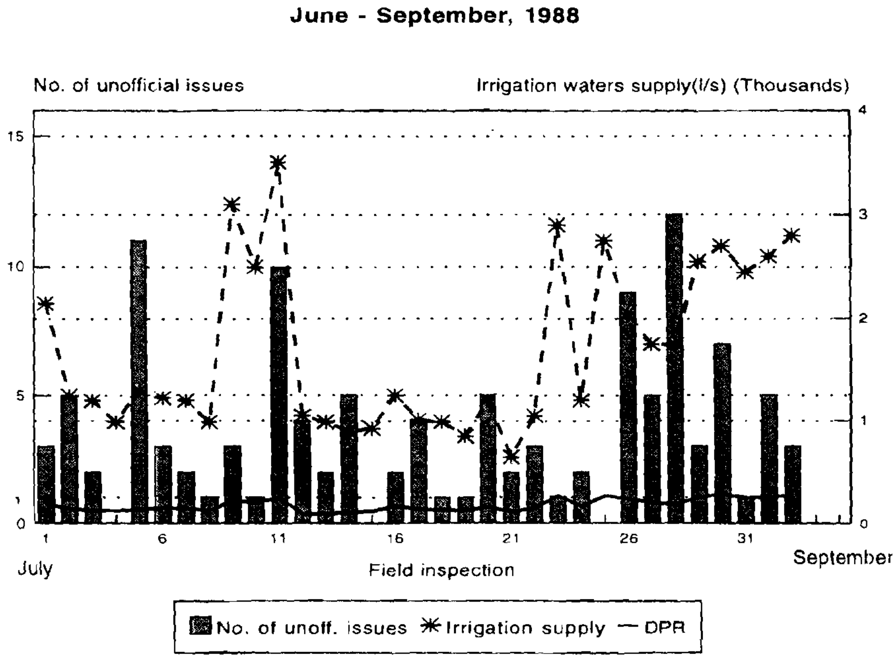
Table 6. *Rotation plan and actual practices observed at sample locations, day-and-night inspections, the East Maneungteung System, West Java, 1988 and 1989 dry seasons.*

Tertiary blocks	Planned				Unplanned practices			
	Delivered		Not delivered		Delivered		Not delivered	
	1988	1989	1988	1989	1988	1989	1988	1989
MTR V	2	7	12	30	2	5		
MTR VI	2	9	12	24	2	6		3
MTR VII	2	9	3	23	11	9		1
PB I	1	9	6	32	11	1		
PB II	2	9	9	17	7	16		
PB III	2	10	8	27	8	5		
PB IV	2	10	12	29	5	2		1
PB V	3	7	11	33	3	2	1	
PB VI	4	7	11	35	3			
PB VII	4	7	11	35	3		1	
PB VIII	3	7	11	35	2		1	1
PB IX	2	7	14	34				
JTS I	3	7	1	15	10	20		
JTS II	3	7	1	28	10	6		1
JTS III	4	7	1	12	10	23		
JTS IV	4	7	3	30	6	4	1	1
JTS V	3	7	4	28	5	6	1	1
JTS VI	4	7	4	28	5	5	1	2
LS I	3	9	4	17	4	16		
LS II	3	9	4	30	4	3		
LS III	4	4	7	35	1	3		
LS IV	3	4	7	33	1	4	1	1
LS V	3	4	6	37	2		1	1
LS VI	3	4	6	37	2	1	1	
LS VII	3	4	7	37	1	1	1	
LS VIII	3	1	7	38	2	2		1
LS IX	3	1	8	40			1	1
LS X	3	1	11	39		1	1	1
LS XI	3	1	11	40			1	1
LS XII	3	4	11	35			1	3
Total	87	186	223	913	120	141	14	20
Average/Ins.	2.64	4.429	6.76	21.74	3.64	3.357	0.42	0.476
Percentage	20	15	50	72	27	11	3	2

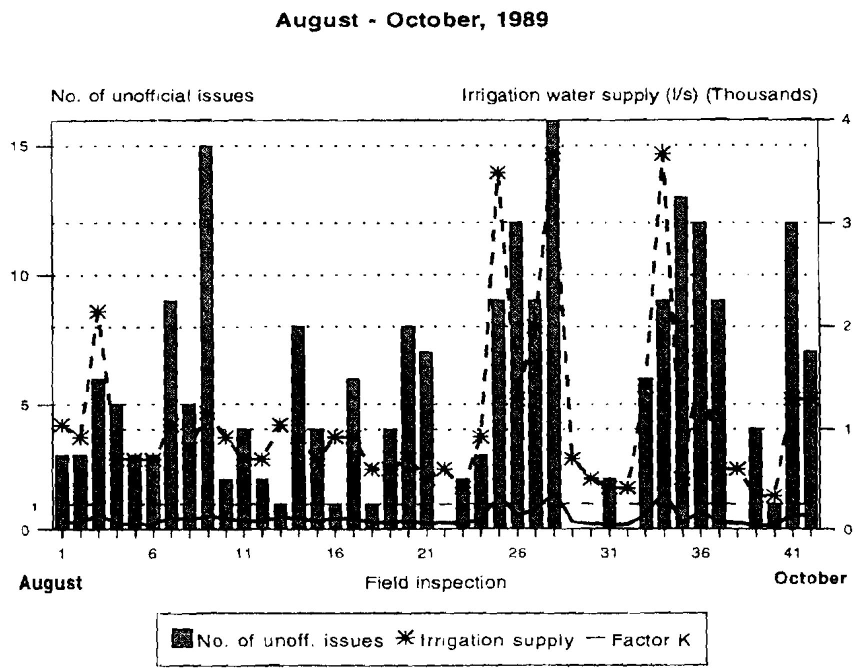
Total observations in the dry season 1988: 444/ No. of inspections: 33.

Total observations in the dry season 1989: 1260 / No. of inspections: 42.

Figure 9. Water supply and frequency of unofficial irrigation issues during rotation period, the East Maneungteung System, West Java.

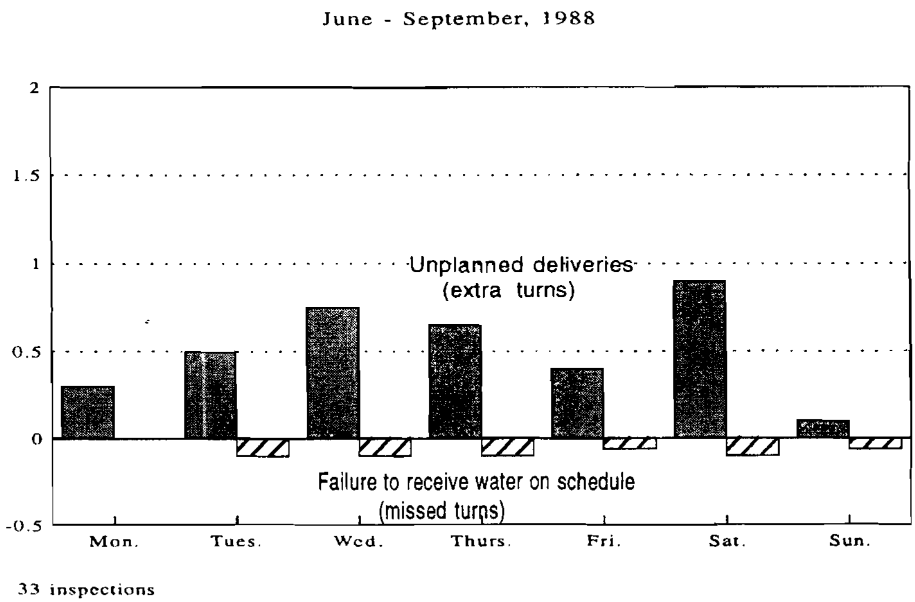


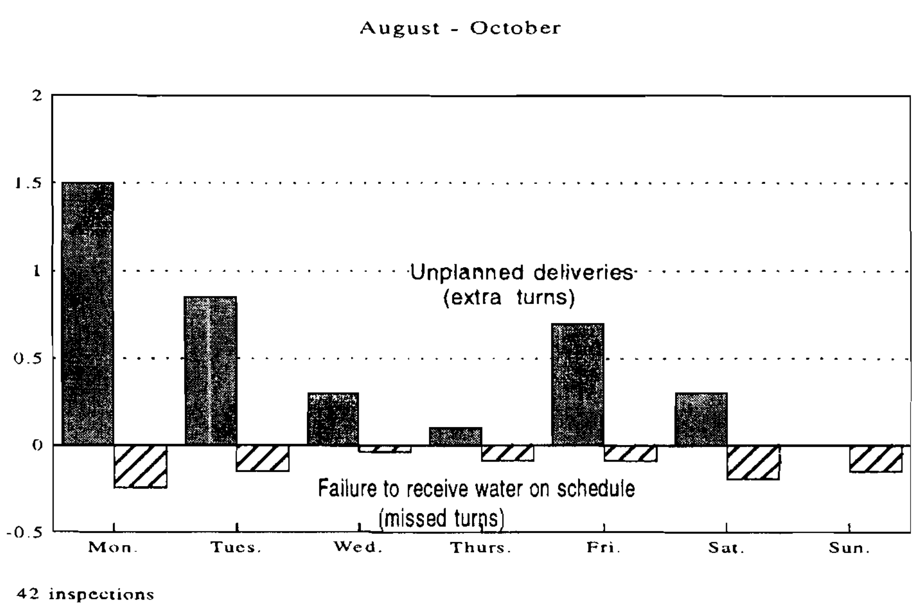
$R^2 = 0.02$



$R^2 = 0.303$

Figure 10. Average number of observed deviations from the rotational plan per inspection, the East Maneungteung System, West Java.





Of course, the major weakness in accountability of the old and new rotation systems is the continuing lack o sanctions against violating the plan, either for farmers, the village officials or the PRIS staff.

How Supportive Are the Incentives for Staff?

The average irrigation inspector receives a monthly salary of approximately US$30.00 to US$40.00 plus a rice allocation. A small travel allowance for field work is also provided, although there is no difference in the amount between dry and rainy seasons. Unofficial incentives or temptations to reallocate water according to special interests, can easily exceed the level of salaries. Furthermore, the PRIS staff, often and understandably, have sideline income-earning activities which often compete for official time.

How Measurable Are the Results?

Actual deliveries to rotation units on any given day could be monitored due to the realignment of unit boundaries according to locations of adjustable gates, nearly all of which had discharge measurement devices. Figure 11 shows the relationship between water adequacy at the system level and at the rotation unit level, and at the same points in time. Water adequacy is indicated by the Delivery Performance Ratio (DPR), the ratio between actual and planned deliveries. In 1989, there was a much closer correlation between the DPR at the system level and the DPR at the level of the rotation unit level ($R^2 = 0.44$), than was the case in 1988 ($R^2 = 0.27$).

In 1989, whenever the DPR was less than 1.0, the scheduled rotation unit received virtually all the water. When the DPR was more than 1.0, the scheduled area tended to receive slightly more than its share, but not substantially so. Surplus water tended to be directed to other blocks not scheduled for irrigation. This contrasts sharply with the situation in 1988. There was a much closer link to water management at the main and subsystem levels in 1989. The DPR was introduced to the PRIS staff at this level and was discussed during the rotation period as a performance monitoring tool.

Progress, Problems and Adaptability

The 1989 experimental rotation system is a far more manageable one than the prior rotations used in the area in terms of specificity of objectives (especially equity of unit areas), implementability, reduced management requirements and measurability of results. It is somewhat improved in the adequacy of human resources (regarding farmer participation in approving and policing the plan) and control. However, it is not significantly different from the earlier rotation in manageability in terms of staff accountability and incentives.

Despite the improvements made in the pilot rotation, a number of problems remained and some corrections were still needed, such as the following:

* From the experience with the 1989 rotation it became clear that tail-end areas should receive water on Mondays, Tuesdays and Wednesdays in order to provide maximum control by irrigation staff over gates at the head end on full working days;

Figure 11. DPR at system and rotation unit, the East Maneungteung System. West Java.

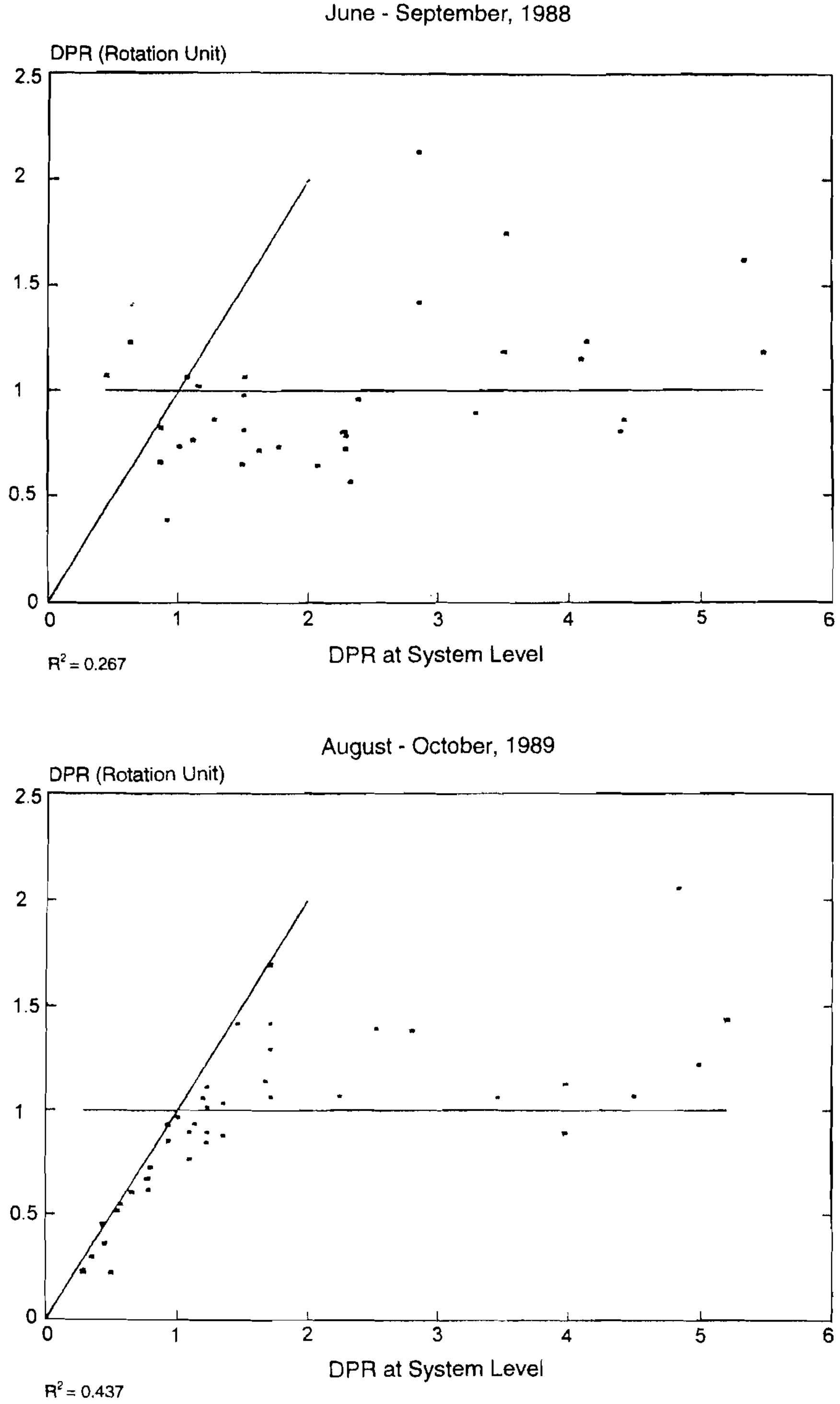
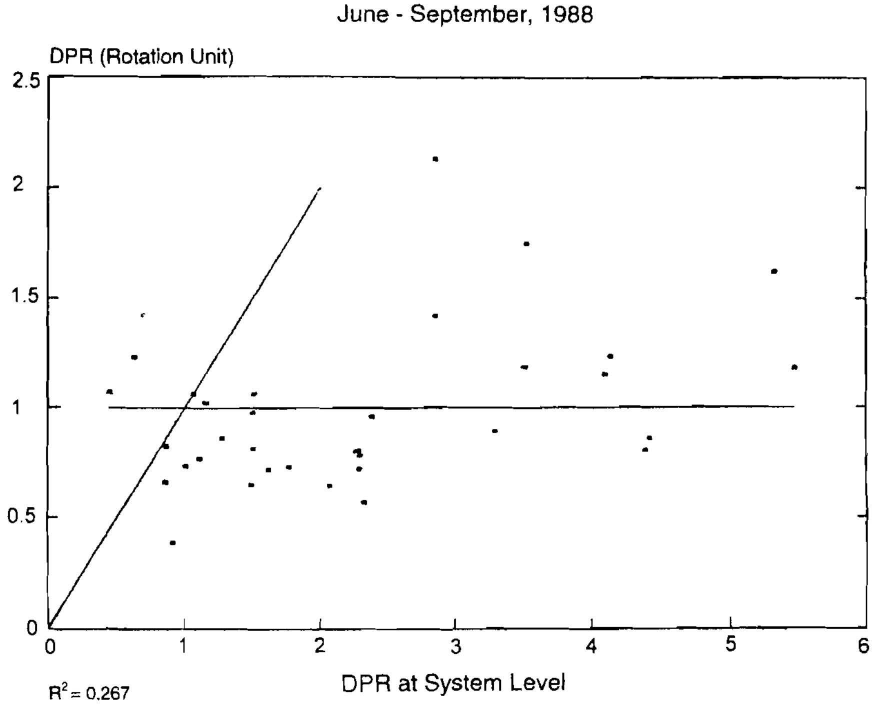
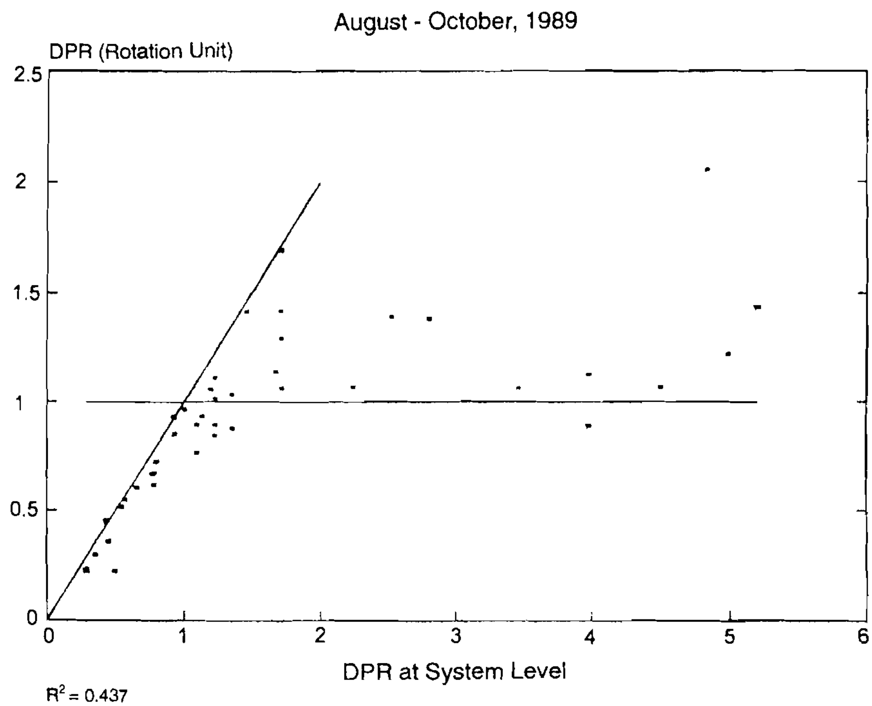


Figure 11. DPR at system and rotation unit, the East Maneungteung System. West Java.





* Head-end areas should be irrigated on Fridays, Saturdays and Sundays in order to minimize supervision requirements of irrigation staff, focusing monitoring on a few structures along the main canal;

* Rotations should be implemented as soon as discharge for the Maneungteung East Canal reaches about 3,000 l/s rather than using factor-k or waiting for river discharges to drop;

* Minor adjustments should be made to daily rotations so that the local problems encountered in 1989 can be smoothed out, such as unexpected problems in irrigating certain tertiary blocks simultaneously because of deteriorated canal conditions;

* Village and local government officials should be kept informed of the problems associated with implementation so that those who break the agreed rules can be sanctioned;

* Switching between rotations should be done at midday rather than at midnight to simplify and clarify the plan and facilitate greater control;

* On a given night, night-guard teams should be mobilized from the area having the rotation turn (to enhance their incentive to guard diligently);

* A system of sanctions against violations needs to be developed;

* The PRIS should receive some form of bonus for extra work or favorable results from implementing the dry-season rotation (although this would require more basic institutional changes); and

* Higher-level policy analysis and discussion need to be pursued regarding institutional reforms which are needed to provide the PRIS with greater institutional incentives to improve not only dry-season rotations but irrigation performance generally.

Conclusion

FINDINGS

THIS STUDY SHOWS that significant improvements can be made in the manageability and performance of dry-season irrigation rotation at the local level using current resources. These include improvements in aspects such as the configuration of rotation units, scheduling, staff assignments and involvement of farmers in planning decisions, and their enforcement. However, such adjustments do not address, and by themselves cannot overcome, management control problems connected with weak staff-incentives and accountability and the "rent-seeking" patterns of water allowance which are driven by underlying economic and land-tenure inequalities, which, in turn, are especially manifest during periods of scarcity (Repetto 1986).

Further, needed improvements in staff incentives and accountability, sanctions and the adaptability of the PRIS to changing agricultural preferences of farmers will require more basic institutional and policy changes. It is becoming widely recognized that irrigation line agencies around the world, which are generally funded by national or provincial revenues, normally lack the institutional imperative to achieve and monitor performance objectives (Small et al. 1989).

Improvements in water distribution according to the rotation plan and the decreased tampering under the pilot rotation can be explained partly as a result of the effect of concerted attention on staff activities in the pilot study, more support from farmers due to a generally more acceptable rotation plan, more explicit public commitments to the plan by the PRIS and village representatives, made in advance of implementation, and the greater ease of implementing and supervising the new plan.

When water is in short supply, rotational irrigation represents one of the larger management challenges for irrigation staff. Water becomes more valuable to farmers, competition increases, and management tasks are more complex and more intensive. However, there is no commensurate increase in management resources. The main observations from the study indicate that there is potential for achieving moderate but immediate improvements in equity through the joint strategy of a) altering rotations to make them more manageable under local resource constraints and b) involving farmers in planning and enforcing implementation.

Awareness of Objectives

Rotational plans in Maneungteung did not provide equitable access to water. Up to 1988, the cropping pattern at the time rotations were introduced determined the overall plan. This means that over a period of several years upper-end farmers had established a precedent for scarce water, while tail-end areas had a high proportion of fallow.

Further, the area scheduled for irrigation each day was also inequitable, so that the value of factor-k each day shows significant variation: some farmers getting water every day, others once a week.

If the dry season starts early, crops may suffer water stress, while a continuation of the rains may mean that nearly all farmers obtain a full crop in the first dry season. Excessive dry-season planning of high-water-demand crops such as rice or shallot can place extreme pressure on the PRIS to implement rotations; if the farmers had known about the typically conservative crop plan and had followed it, it would have been unnecessary to implement rotations.

Existing Management Complexity

Conventional rotational plans observed were too complex for existing management capabilities. They required too many gate operations and too much supervision of gates. The Maneungteung pilot study showed that it is possible to reduce the work load significantly while improving equity, and to do this at minimal cost. The pilot experiment shows that it is a reasonably straightforward task for irrigation managers to reassess their current rotational plans, determine how to reduce overall gate operations and thus make more time available for supervision and monitoring. In Maneungteung, it proved easy to modify rotational plans to take full advantage of suitable locations where water could be properly controlled or flows stopped. It is easy to slip into the habit of designing rotations based on the administrative division of a system rather than developing one that makes the best use of the control infrastructure and available staff.

New Rotational Plans

Developing new rotational plans is a gradual process involving negotiation and testing. The experience of Maneungteung in 1989 shows that it is possible to modify rotational plans to achieve greater equity, and to implement these plans without major difficulties. However, patience and committed leadership are required in all stages of the processing: planning, implementation, supervision and evaluation.

RECOMMENDATIONS

Objectives of Rotational Plans

Rotational plans should specify clearly what the objectives are. When water is scarce it is important to clearly define the equity principle to be adopted, and to develop a rotational plan that meets that objective as closely as possible given the limitations of physical infrastructure and the canal layout.

The fairest way to achieve equity is to use the total irrigable area as the basis for water allocation, thereby giving tail-end farmers an equal right to water. If this proves difficult because of conveyance problems, rotations between seasons to different parts of a complex system should be considered.

Preknowledge of Rotational Plans

Rotational objectives and procedures must be known in advance. If rotational plans are to achieve their objectives then farmers must know of these plans before they plant their dry season crops. Decreasing the level of uncertainty can only help farmers to be more productive.

Rotational plans based on clear objectives do not reduce the overall risk, but can provide assurances of priority to water if it is less than adequate for all areas. Traditional rotation plans were based mainly on area planted and hence gave priority to those who planted more. These tended to be located in areas with better access. By redefining and clarifying the equity objective (i.e., based on irrigable, not planted, area) the risk is spread out among more farmers because each person is entitled to a share of the available water. If water becomes scarce, the effect is felt equally, and it becomes the choice of individuals to decide whether to irrigate all or part of the cropped area.

Simplicity of Rotational Plans

Rotational plans should be as simple as possible to be understood and implemented. Where possible, the plan should call for gates to be either open or shut so that control over water is simpler and easier to monitor. Developing plans so that several adjacent tertiary blocks can be irrigated rather than tertiaries on two or three secondaries greatly reduces management and supervision tasks.

Implementability of Rotational Plans

Rotational plans must be implementable with existing physical infrastructures. If main or secondary canals had to be blocked at the downstream limit of a daily rotational area, this should be at a gate that is functional and where proper control can be maintained. The plan should aim at minimizing the lengths of canals that have to be filled and emptied to achieve a full rotational cycle; travel time allowed should also be minimized when determining the area to be irrigated each day. It is not easy to develop a rotational schedule that fits a system design based primarily on continuous flow. However, until such time as management implications of rotations are included in the design process, it is incumbent upon system managers to adopt as efficient a system as possible within the design constraints.

Speed of Implementation of Rotations

Rotations should be implementable quickly and on the basis of appropriate criteria. Delay in implementing rotations means that some farmers will suffer more than others. These are always tail-end farmers, because breakdown in hydraulic conditions will not be felt near the head of canals. The use of factor-k to determine when to implement rotation should be modified to include assessment of the percentage of design discharge flowing in canals, while field monitoring should be used to determine when tail-end reaches of canals are beginning to experience conveyance problems and it is time to introduce rotations between tertiary blocks and then between secondary canals.

The use of factor-k to determine when to implement rotations is hydraulically unsound. In a typical dry season, a certain percentage of farmers never plant so that demand is automatically less than design discharge. Factor-k values only assess the ratio between actual demand and supply, and do not take into account the hydraulic viability of running the system at low discharges. The major purpose of rotations is to maintain flows closer to design levels than would be possible if continuous flows are adopted. The result is that water distribution under continuous flow conditions may become very difficult even when factor-k is still high because demand is much lower than in the wet season. Implementation, therefore, should be based on an assessment of both the level of actual demand in the system and the adequacy of current discharges relative to hydraulic flow parameters in the system design.

Controllability of Rotational Irrigation

Rotational irrigation must be controllable. There is little utility in developing a rotational plan if it is not enforced. In areas where rotations have to be introduced every year it is essential that farmers have enough confidence in the system management that they will risk planting a dry-season crop, or risk planting a more valuable dry-season crop.

This confidence can only be developed over a period of several seasons, and this requires a consistent set of plans and implementation by irrigation staff. It is essential that the agreed plan is implemented in accordance with that agreement, and that violators are brought to task. Nothing will erode the confidence of tail-end farmers more quickly than seeing upper-end farmers taking water out of turn, or successfully offering inducements to irrigation staff to break the schedule.

Because rotational irrigation affects the whole community, it is important that the whole community is involved. This involvement goes beyond planning, and includes active farmer and village leadership involvement in supervision, monitoring and sanctioning activities. It is impossible for irrigation staff to undertake these tasks because there is neither the time nor the manpower available to supervise rotations unilaterally.

Conditions for Accountability

Supportive organizational arrangements should exist to ensure accountability. To facilitate the implementation of rotational plans, the boundaries of rotational areas, where possible, should coincide with the jurisdictions of irrigation inspectors in an effort to reduce the amount of coordination required. It is not desirable, however, that only one irrigation inspector be fully responsible for a single day of the cycle because the supervision load is too high. Plans should include a system of mutual assistance between irrigation inspectors so that those who do not have duties on a given day, because there is no water in their area, can assist in the monitoring and supervision in other parts of the system.

It is important that once this innovation has been started it is pursued and further refined over several seasons to ensure that the plans are as easy to manage as possible, that all parties are reasonably satisfied with the arrangements, and that difficulties encountered can be accommodated by making adjustments in the successive seasons. Making changes to rotational irrigation should not be seen as a one-time, project-type of activity, but the development of a long-term process that deals with the particularly difficult task of managing irrigation when there is insufficient water for all concerned.

This pilot experiment was an exercise where an international irrigation management organization collaborated with an administrative line agency to develop, implement, and evaluate an improved irrigation management procedure which is based on standard management principles of specifying clear objectives and implementable procedures to achieve easurable results. Line agencies often function less to achieve results than to implement administrative routines as prescribed from above. Frequently, agency staff pay little attention to whether or not the procedures were actually implemented or the results achieved. A pilot project such as this concentrates special attention on management activities. This alone can stimulate improved performance and no doubt was partly responsible for the improved performance measured in the second year of the study. This shows that the identification and application of locally appropriate management procedures can have a direct effect on improved performance.

However, the experiment also supports the view that the institutional accountability and incentive to manage, and not the identification of management procedures, constitute the hard part of the challenge in improving and sustaining irrigation management performance. Various new management activities were carried out on the momentum of a pilot research and development project. The Study Team members and agency staff discussed equity and management objectives and identified ways to link new implementation procedures to the newly clarified objectives. Farmers were included in designating main system rotation units and in policing implementation.

And yet the experiment was not able to fully address the more fundamental problems of control and incentives. In order for this "management approach" to be sustained by the implementing agency, its own institutions must be reoriented towards a *"need to manage."* There must be an institutional imperative to clarify objectives and achieve results. This more difficult challenge remains to be addressed.

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