Enhancing the Manageability of Rotational Irrigation in Indonesia: A Pilot Experiment in West Java

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Suggested note about the publication:

This study analyzes the formation, implementation and results of a modified pilot experiment for rotational irrigation which was conducted in a 7,116 hectare system near Cirebon, West Java in Indonesia.

Suggested note about the authors:

Both authors are staff of IIMI. Dr. Vermillion is a sociologist who worked for IIMI in Indonesia from 1986 to 1989. Dr. Murray-Rust is an agricultural engineer who worked for IIMI in Indonesia from 1988 to 1989. Dr. Murray-Rust has also done research on irrigation in Pakistan, the Philippine's and Sri Lanka. Both are currently assigned to IIMI Headquarters in Colombo, Sri Lanka.

Forward

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 (See 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 three-fold: 1) its well-diversified cropping patterns, 2) its relatively well-maintained irrigation control and measurement structures, and 3) its annual use of irrigation rotations in the dry season, which are required by the water scarcity related to the system's weir being 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: 1) to analyze current rotation practices, 2) to develop and field test an improved rotation system and 3) 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 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.

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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 this study and others in which IIMI was involved. They have been open and supportive to this study.

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Chapter One: Introduction

1.1 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 effective and efficient irrigation O&M in Indonesia and 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 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--namely, rotational water distribution during 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 experiment and innovation 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.

1.2 The rationale for rotational irrigation

There are three primary reasons why rotational irrigation is practiced: 1) shortage of water to meet irrigation requirements, 2) conveyance difficulties when discharges are significantly below design capacity of canals and 3) the need to avoid over-irrigating non-rice crops that are susceptible to yield reduction under conditions of excess water. This paper focusses on the first two reasons because they involve modifications to normal operating practices of rice-based irrigation systems. Rotations for agronomic reasons 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 that the hydraulic relationships incorporated into the design and layout of structures and canals allow gate keepers to maintain adequate discharges into all canals simultaneously.

However, when actual discharges fall below about 60-70% of design discharge it becomes increasingly difficult for gate keepers to, operate control structures to maintain adequate head or stream size into all canals simultaneously. For example, irrigation supervisors in the Haneungteung System use a rule of thumb that the minimum stream size acceptable into a tertiary block is 15 l/sec. 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.

1.3 Rotational levels

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

Rotation within tertiary blocks is 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 or village leaders who initiate and manage rotation among fields.

Among the reasons why farmers use tertiary or field-level rotation 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 the warabundi system of India and Pakistan), it minimizes the risks of over-irrigation 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 gate keeper (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 gate keepers, but 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 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 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 becomes more complicated.

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

The entire system is divided into rotational units comprised of 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 wholely 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 effect 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 level once total supplies fall below 60 percent of 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).

1.4 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 expenses 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 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 apply. The alternatives most often considered by system managers to are:

> Allocation based on 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

> Allocation based on eauitv 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 monltored 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 rmers have limited off farm income sources during 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.

1.5 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 rotational irrigation must have at least seven features in order to be manageable (See Figure 2). These are as follows.

1) ***Clear objectives*** - They should be specific and uniformly understood by staff, there should not be dual or conflicting official vs. 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 (See Levine and Coward, 1989).

2) ***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.

3) ***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 of time or area.

4) ***Control*** - Managers should be able to ensure that the acquisition and use of resources leads 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, involve farmers in supervision or both.

5) ***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.

6) ***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.

7) *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 need for annual reassessment of rotation objectives and procedures. Within seasons, this implies the capacity to adjust to different pre-specified 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, 1988. 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 has been 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 (See Uphoff, 1986).

Chapter Two: Traditional Rotation in the Pilot Area

2.1 Conditions in the Haneungteung 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 Cirebon Regency.

Average annual rainfall is in the order of 1800 mm, concentrated largely in the wet season between November and May. This rainfall, combined with high available discharge at 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 red onions, chilies, green beans, mung beans, corn, and groundnuts 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 able to cultivate a third crop during the peak of the dry season.

The upper end of the East Maneungteung Division (hereafter "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 sugar cane cultivation in the upper and western parts of the system, where as much as 50% of the land may be under sugar cane at any time. Because sugarcane production involves deep trenching of fields and leaves a lot of undecomposed 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 farmer3 rely on shallow groundwater to supplement canal irrigation supplies.

Historically cropping intensities in the lower parts of the system rarely exceeded 160%, but in recent years there has been a large increase in the area intensively cultivated to red onions 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 heads of most secondary canals, and at the intake at 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, and also permits a wide range nf different rotation options.

2.2 The basis for rotational irrigation in 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/sec/ha. Allowing for conveyance losses in secondary and main canals, the intake at Cikeusik weir and the first 8 kilometers of the main canal are designed for 1.5 l/sec/ha, or 11.0 m3/sec. 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 system.

In the dry season, available discharge in Cisanggarung River is normally about 2000 l/sec, and may fall below. 1000 l/sec In, particularly dry periods. This means that actual discharge is typically only 20% 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 rotations 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, 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 Cisanggarung River at the end of the wet season. Rotations normally have to be implemented in late June or early July, and are maintained up until the end of the dry season at the end of October. On November 1 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 1970's as part of the wider program of upgrading irrigatlon systems in Java.

2.3 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 a third, or even second, crop while other areas consistently were 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 systems, or at section level if the rotational units cover more than one sub-section.,. In Maneungteung rotational plans are drawn up at section level because the system has three sub-sections.

Once the initial plan has been drafted, it is presented to the meeting of the Irrigation Committee for the sub-district' (kecamatan) held in March. This meeting includes representatives of the Provincial rrrigation Service (PRIS), Agriculture and local government (including village leaders). The rotational plan is discussed and approved at this time. At the meeting in 1988 the proposal drafted by 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 (Hurray-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 is the responsibility of the section or subsection engineer who decides 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 informing by letter 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 letter and commencing rotations has to be in the order of 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 accommodate 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 Losari Secondary were scheduled for water two days a week, and 67 tertiaries were scheduled to receive 'water once a week (Figure 3).

2.4 Implementing the 1988 rotation

In the 1988 dry season in the East Maneungteung system, rotational irrigation at both tertiary and secondary level was implemented only after overall water supplies had become far lower than could be accommodated by continuous irrigation (See Figure 4a). At the beginning of June discharge in Cisanggarung River was about 8,000 l/sec, which was approximately twice the level of demand in the entire system, which was about 4,000 l/sec. (Figure 4a). By late June available discharge had fallen to about 3200 l/sec and shortly after quickly passed below the system demand of about 3000 l/sec in early July. It was only at this time that the decision to implement rotations was taken, and the appropriate letters issued.

However, discharge in Cisanggarung River 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 in severe 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 deseribed in a number of ways:

- the number of days per week that different tertiary blocks received water during the rotational period varied from one to seven;
- the total irrigable area scheduled for irrigation each day of the week ranged from 403 ha on Fridays to 1331 ha on Mondays (Figure 5a);
- the total area planted in each rotation unit ranged from 369 ha on Fridays to 1107 ha on Mondays (Figure 5a); and
- the estimated demand for water each day of the week varied greatly--although the time allotted per rotation unit was the same; this ranged from a low of 253 l/sec for the Friday rotation unit to a high of 805 l/sec for the Monday unit (See 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. This clearly favors head-end farmers who can get an early start to the first or second dry season crop and are more willing 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.

2.5 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 simple administrative boundaries or agricultural quotas. From repeated day and night inspections and interviews with 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 meters on Wednesdays to 23,074 meters 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 (Figure 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 to 50 per month, plus rice. Salaries for gate keepers were about $15, some of whom received rice as well);

- there was inadequate policing, farmers were not involved; and

- 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

This is a complex situation with numerous factors leading to the observed outcome. It was reported that in some cases that much of the unscheduled activity was due to illegal operation of gates by farmers, and in others due to tacit consent of gate keepers.' It is difficult for the PRIS to supervise head and middle section gates, especially since there are a high 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 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 because the plan itself was 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, a total of 52 gates had to be opened and 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 was a total of 60 gates per week which had to be kept closed 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% 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% of cases were water was not delivered when it was planned for delivery, and 15% when deliveries were made but 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.

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% of design, and hydraulic conditions have already started to deteriorate.

Chapter Three: The Pilot Experiment

3.1 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 level, 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 solelythrough 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 supervise 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 committment to the rotation plan among the farmer community. Whereas earlier the PRIS subsection head 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 PRIS and obtain their advice and consent, and perhaps even' their assistance in implemented it.

After these priciples were agree to it was 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, village agricultural officers and 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 the various PRIS staff and farmers involved in the rotation, the Study Team helped 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, amenability of the plan to being controlled and enforced). 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 various of the specified criteria.

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

6) A meeting of 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 reach agreement on one.

7) Shortly after the above meeting to nominate the new rotation plan, the meeting was held with all involved PRIS subsection staff, agriculture and local government officials, and village agricultural officers to discuss alternative rotational plans and select one of them. In this meeting the farmer representatives agreed in principle to the plan nominated by 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 night time rotation.

8) The Study Team held a planning and training meeting among 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 PRIS subsection head, in accordance with criteria about level of water shortage agreed on with village agricultural officers, decided on 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 where 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 harvest of the second dry season crop in late October.

12) The Study Team monitored implementation of the rotation through systematic day and night inspections along distributary canals and interviews with farmers and agency staff. It then analyzed the data

and produced and discussed reports in subsequent meetings with PRIS and DOI.

3.2 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).

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 rotational 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 PRIS staff, 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.

This alterhative 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 variation in total irrigable area varied from 564 ha on Tuesdays to 842 ha on Mondays a ratio of only 1.49 compared to 3.30 in the 1988 plan (Figure 7);

- a reduction in the number times when gates have to be either operated or monitored (ie. "management inputs") from 279 in 1988 to 241 in 1989 (a 13.6% decrease), and a decrease in the number of total required gate operations (ie. 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 when gates merely have *to be* monitored to ensure they remain closed from 16.0 in 1988 to 17.7 in 1989, a 10.7% increase (Table 5).

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.

However 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 have 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 of their land.

It was decided by the Provincial Irrigation Service (PRIS), after discussions with 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.

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 risk high cropping intensities. Head end areas, scheduled to receive water between Monday and Thursday, had cropping intensities in August 1989 that averaged 97.7% (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% and 27.0% 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.

3.3 Assessing the manageability of the pilot rotation

We now return to the seven aspects of manageability referred to in Chapter One (section 1.5). We will apply them to our assessment of the rotational management pilot experiment.

How clear are the objectives?

Prior to the pilot experiment the new PRIS subsection chief was unaware of the criteria used to establish the earlier rotation. It was clear to him and 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 it should be based on equity of rotation unit areas (not cropped areas or real demand), it should be practical to implement, and it should be subject to management control. Clearly equity of the area sizes of rotational units (with unit size being somewhat inversely proportional to distance from the headworks) was a key objective (Figure 7).

How implementable are the procedures?

The new rotation, which was identified by the Study Team and selected by 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). Also, because of the discussions and preparations which were made in advance, the 1989 rotation was able to be implemented 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 adeouate are the resources?

Given the smaller amount of gate adjustments and monitoring that was 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 at least had bicycles for transport, although night time use of bicycles to tour the system was considered somewhat dangerous, if 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 midnight and involving farmer rotation unit representatives in nighttime policing helped substantially to make the rotation more controllable by PRIS managers. Farmer night watch groups were observed to be functioning on most night inspections. . However, partly due to the inadequate incentives of Staff, night-time field work by 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 not being able to find PRIS staff at their homes at night in order to correct unofficial diversions or of having the diversions return to their illegal positions after they had been corrected earlier in the night. There were some accounts complicity between farmers and low-level PRIS staff in some of the. unplanned water deliveries.

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