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IMPROVING IRRIGATION MANAGEMENT THROUGH BETTER INFORMATION: TESTING PRACTICAL OPTIONS IN INDONESIA

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1. Objectives of the Management Information Project

The purpose of this paper is to demonstrate that it is possible to significantly improve the information required for effective demand-based irrigation management at a relatively low cost, using simple techniques that are within the capabilities of the field staff of irrigation agencies.

In Indonesia, much of the data used in calculating water demand and supply is based on assumed rather than measured values. Because of the frequent lack of effective monitoring and evaluation, the information base used for water allocation has tended to become routinized, and there is a general lack of sensitivity to actual field conditions. Also, water distribution plans often cannot be effectively implemented because discharge measurement facilities are frequently inaccurate or broken, thereby impeding the ability to monitor whether water distribution plans are being followed.

This report describes the results of a pilot experiment and training program, called the Management information Project (MIP). It was conducted in West Java, lndonesla in 1969 as part of a wider study of Efficient Irrigation Management and System Turnover funded by the Asian Development Bank and the Ford Foundation. The training program was developed under a collaborative program between the international Irrigation Management Institute (IIMI), the Directorate of Irrigation I, and the West Java Provincial Irrigation Service (PRIS) of the Public Works Department. The methods were pilot tested in the Rentang, Ciwaringing. Ciherang and Maneungteung (or Cikeusik) irrigation systems in West Java. The methods have iargeiy been adopted as standard operating procedures in several parts of West Java.

The main objective of the Management Information Project was to develop methods for providing a minimum set of information required by the demand-based management system used in technical systems. Methods sought were those which were simple, inexpensive, reasonably accurate and widely applicable using local resources. Table 1 summarizes the criteria for identifying the methods.

Table 1. Criteria for methods used in the Management *Information Project.*

Potential for rapid Improvement in *irrigation management performance,* especially in productivity, equity, efficiency, reliability. or sustainability.
Inexpensive, not too complicated for local application, and capable of widespread dissemination.
Not dependent on special project personnel
Can be directly incorporated into *the* current management system rather than developing alternative systems that require more basic and extensive changes in policy, administration, or physical infrastructure.
Methods which develop local capacities for low-cost Operation and Maintenance (O&M) management activities rather than relying on construction-oriented projects that develop procedures difficult to maintain once project *funding* has ceased.

2. Key Gaps in the information Base

Most of the provincial irrigation services in Indonesia have adopted a demand-based water allocation process known as the "Factor-K System." Although there are differences in the way water demand for each tertiary block is calculated, the basic principles are essentially the same.

Every 15 days (10 in East Java) tertiary-level demand is assessed by determining the area of each crop being irrigated, modified by an assessment of expected cropping changes that will occur in the next irrigation period (more details are provided in Appendix 1). Using standard values for soil-crop-water requirements and including an allowance for tertiary-level irrigation efficiency, a target discharge for each tertiary block is determined. These tertiary-level targets are then cumulated to secondary level, a conveyance loss factor applied, and the process then repeated at main canal level. The result is a set of planned discharges at each tertiary and secondary offtake and main intake throughout the irrigation network. As long as the estimated water supply at the head of the system is greater than the target discharge at the system head, the operational plan uses these target discharges.

When estimated supplies are less than the total demand, an adjustment factor known as Factor-K is used to modify all target discharges. This is based on the ratio between the estimated demand and the estimated supply at the system head. When Factor-K is between 1.0 and 0.6, all discharges are multiplied by the value of Factor-K *so* that the deficit is equally divided between all parts of the system.

Once Factor-K falls below 0.6, then rotational irrigation between tertiaries is implemented. When Factor-K is less than about 0.4, rotations between secondary canals are implemented in order to maintain discharges more or less at design level during each rotation.

Factor-K is a logically valid and compelling system for managing water allocation and delivery on the basis of measured demand and supply conditions. However, it contains stringent assumptions about information and control. These assumptions are oflen difficult to fulfill in a country as physically and agriculturally complex as Indonesia. A recent government paper on operational procedures noted that the Factor-K System depends "on accurate data and it requires infrastructure in good physical condition." It also requires "well motivated and skilled staff: rapid communications and transport ... and the ability to enforce the annual crop plan." (Directorate of Irrigation 1 et al. 1990, p.8)

And yet, observations throughout Indonesia suggest that such conditions more oflen do not exist in systems where Factor-K is being applied. Under the current irrigation development programs assisted by the World Bank and the Asian Development Bank, the Government has selected pilot Advanced Operations Units at irrigation field office levels from among systems with the best technical infrastructure and staff, in order to implement improved reporting and operational procedures for Factor-K or FPR: see Appendix 1. There are indications that inadequate measurability of water supply/demand parameters is making it difficult for many of these systems to implement the improved Factor-K procedures.

For example, the Jurang Sate System in Lombok has difficulty in using the Factor-K method because extensive drainage reuse complicates calculation of actual water requirements. In West and Central Java, faulty measurement and control structures, extensive hydraulic interconnectedness between systems and blocks, and inadequate information about actual local conveyance loss rates hamper effective implementation of Factor-K. The poor condition of measurement and control structures in South

Sulawesi and **West** Sumatra. prompt the **use** of assumptions rather than measured information in calculating water supply and demand for Factor-K. (DOI-1 **et al.** 1990)

If the above-mentioned assumptions about measurability and control are not used the whole process, if rigidly followed, may become an administrative exercise detached from reality. Vast investments in "technical" irrigation systems have been made in Indonesia, based on the assumption that the ***pasten*** (sharing) management system (or its Factor-K or FPR derivatives) would be used (see Appendix **I).** The first step in reaping the benefits of this investment via the Factor-K system is ensuring that the requisite information about supply and demand can **be** obtained.

The Government recognizes that Factor-K is not appropriate for all **irrigation** systems in Indonesia. Determining which kinds of systems are appropriate for Factor-K involves finding out to what extent essential information on supply and demand parameters can be obtained in different types of settings. Hence, high priority was given in the IIMI-Directorate of Irrigation Research Program on Irrigation System Management to: (1) assessing the information base for Factor-K management, and (2) identifying simple, low-cost methods for obtaining a minimum required database in diverse settings where hydraulic and agricultural conditions were complex and infrastructure and staff resources were suboptimal.

The research team found that in several provinces in Java and Sumatra there were several kinds of basic gaps between information used by irrigation agencies and values measured in the field. The most important findings were:

- Official records of tertiary block areas need to be revised periodically because of changes that occur in irrigated areas and water supplies over several years of operation, and the use of additional water sources developed by farmers should be taken into account.

- It is difficult for irrigation inspectors in the field to accurately estimate every 15 days, the area under different crop types throughout the approximately ***750*** ha (hectares) for which they are responsible (on the average), without tertiary block maps which delineate farm boundaries. This is partly because in many areas there can be much variation in cropping patterns between individual farmers within the same block.

- Assumed values for conveyance **losses** must be replaced by actual measurements to account for high local variation.

Due to study team findings about problems in implementing operational plans, it was decided to address Four additional needs in the training agenda. **These** problems were:

- Lack of effective monitoring and evaluation of water delivery performance to check whether target discharges have been achieved.

- Insufficient information on the conditions of gates and control structures to enable engineers to determine whether operational plans can be effectively implemented, and Io support rational maintenance planning.

- Lack of good information on the condition and accuracy of discharge measuring devices

- Lack of good information on management problems and needs of Water Users Associations (WUAs). WUAs play a vital role at tertiary and even secondary levels in water distribution, implementing the annual crop plan and maintaining watercourses.

The joint IIMI/Public Works Study found that in the majority of systems, the calculation of water demand was based more often than not on assumed data rather than measured values of current, local conditions. This means that the apparent precision of the calculations used to develop the operational plan was in reality only an approximation. The objective of the Management Information Project (MIP) was therefore to seek ways of addressing these inadequacies through a series of field activities aimed at supplying reasonably accurate measured information required by the Factor-K (or FPR) System. The schedule of activities undertaken through this project are given in Appendix 2.

To achieve this objective, the Project developed five specific tasks that were undertaken by the field staff in the training program. These were:

- Mapping of tertiary blocks to determine the total irrigable area served by each gate, the area of each landholding, the presence of any additional water supplies from rivers or drainage canals and locations using supplementary water, and the current quaternary canal layout.

- Inventory of all gates and control structures to determine their current condition and effectiveness.

- Calibration of gates and measuring structures to enable discharges to be properly measured and used in monitoring procedures.

- Measurement of conveyance losses in main and secondary canals under different discharge conditions to determine actual conveyance requirements.

- Creating a management inventory of WUAs that assisted irrigation inspectors to understand problems and constraints faced by farmers in managing O&M within tertiary blocks.

It was felt that this set of activities would have the most widespread application and impact and would generally be simple and inexpensive enough to be within the capacities of provincial irrigation services to implement. Collection of other potentially useful information such as measures for field irrigation efficiency or seepage and percolation rates, were not included in this exercise because of the need to first focus on a manageable set of the most important information needs. Eventually, practical methods for obtaining such additional information should be developed and applied in systems where it would be needed and be cost effective.

3. Findings

3.1. IRRIGATED AREAS AND MAPPING OF TERTIARY BLOCKS

A total of **33** tertiary blocks were mapped during the MIP activity in the four **pilot** systems. The main findings can be summarized as follows:

* **The** average area actually **irrigable** was only 87 percent of the official figure.

  In all of the four systems studied, the actually irrigable area was less than that in the official records. The differences ranged from 78 percent in Rentang, to 92 percent in Cisangkuy (Table 2), but the overall conclusion is that use of official records inflates the actual demand at system level, and implies lower than expected irrigation performance.

Table 2. Results of mapping activity—Management *Information Project.*

Sub-section	Number of blocks mapped	Total *official* area (ha)	Actual area mapped				Average size of landholdings	Percent of area irrigated by suppletions	Percent difference between official and measured areas
			Irrigated by gate (ha)	*Irrigated* by suppletions (ha)	*Total* measured area* (ha)	Total landholdings			
Rentang	5	161.80	101.34	24.71	130.20	238	0.49	19	78
Leuwimunding	6	338.00	272.73	3.38	296.63	1,372	0.19	1	*82*
Cisangkuy	1	82.30	75.54	-	78.51	149	0.50	-	92
Maneungteung	21	*841.00*	758.42	-	758.42	1,581	0.58	-	90
Total	33	1,423.10	1,208.03	28.09	1,263.76	3,340			
Average block		*43.12*	*36.61*		38.30	101	0.38		87

* Including roads and channels

* Within each irrigation scheme, there was significant variability between actual and official figures for irrigable area of different tertiary blocks.

  Measurements of individual tertiary blocks in each system showed large differences between actual and official data (Table **3).** In Maneungteung, actual figures ranged from 27 percent to 164 percent of official figures; similar results were found in Rentang and Leuwimunding.

Table 3. Tertiary block areas—Maneungteung Irrigation System, West Java.

Tertiary block	Official command area (ha)	Measured command area (ha)	Percent of official area	Irrigated area outside official block boundary (ha)
HMB I Kr	12	10.44	87	
BMB V Kr	75	74.55	99	
BMB VIII Kn	38	25.27	67	
BMB Xa	68	38.01	56	
BPA IIc Kr	11	14.32	130	
RGR I Kn	172	162.53	94	
BLS V Kr2	41	39.12	95	51 42
BLS V Kr3	37	9.93	27	
BLS VIII Kr	23	21.58	94	25 49
BLS X	35	35.82	102	
BMTR II Kn	16	14.29	89	
RMTR III	85	80.48	95	80.00
BJTS II Kr	22	20.19	92	-
BPB II Kr	61	57.42	94	18.02
BPB III Kr	39	23.09	59	-
BPB VII Kr	36	38.76	108	-
BPB IX Kn2	36	58.87	164	-
BTWS I+II	34	33.45	98	-
Total	841	758.12		17493
Average	46.7	42.1	91 7	

* Farmers often obtain water from sources other than the canal system.

Parts of 4 of the 5 mapped tertiary blocks in Rentang used water from unmeasured streams and drainage channels as their sole source of irrigation water. Areas dependent on such supplemental sources represent 15 percent of the total irrigable area in Rentang. In a number of other cases, water sources such as streams and drainage channels provided supplements to canal water deliveries but did not increase the total irrigable area. The result is that irrigation agency staff often carinot accurately measure all water entering tertiary blocks.

* Several tertiary gates irrigate parts of neighboring tertiary blocks.

In 4 of the 21 blocks in Maneungteung. tertiary gates provide water to parts of neighboring blocks because farmers have found it necessary or easier to get an adequate water supply that way. In these cases, there is no overall change in the total irrigated area among the blocks involved, but there are major differences in the demand at each tertiary gate. The additional area irrigated in these four cases ranged from 30 percent to 125 percent of the official command area of the block.

- Farm parcels are small, boundaries irregular, and cropping patterns variable.

  Average farm parcels ranged from 0.61 ha per farmer in Maneungteung to 0.18 ha per farmer in Leuwimunding. Each irrigation inspector has about 750 ha to supervise, covering over 2,000 parcels that show high variability in individual cropping patterns.

3.1.1. Utility of Tertiary Block Mapping

Although the cost of making maps of tertiary blocks at a 1:2,000 scale, which includes individual landholding boundaries, is not cheap (*see* Chapter 5 below), there are three primary clients for the finished product.

With the maps, sub-section heads have access to accurate information on the total irrigable area within their systems. This enables them to make appropriate calculations of the total demand for each system, and to develop operational plans that reflect the actual disposition of irrigable land.

During the Project, these revised values were used in the new set of O&M forms developed for West Java, used for determining tertiary block water allocations for each irrigation period rather than relying on the out-of-date official areas previously used.

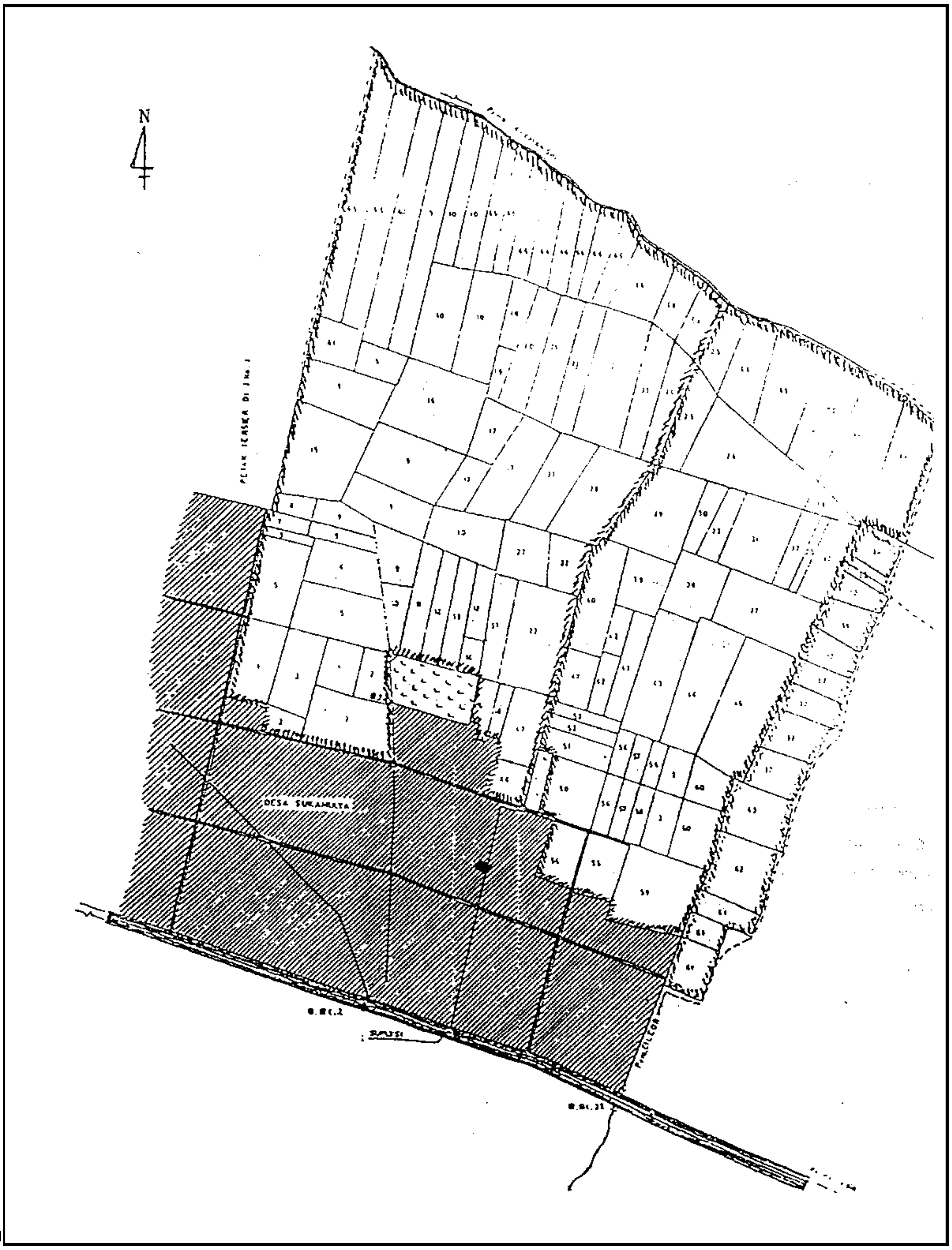
With the map, irrigation inspectors have an accurate basis for calculating actual irrigated areas planted to different crops. They can more readily determine the extent to which non-canal water supplies help meet irrigation requirements, thereby reducing demand on the canal system, and they can quickly see which areas are effectively served from which tertiary gates.

It can be observed in the field that irrigation inspectors are sensitive to these differences between official and actual conditions and they often make informal adjustments to discharges based on their experience. While this is perfectly rational, it has the disadvantage of being impossible to monitor effectively. The only long-term solution is a periodic reassessment of the functional area served by each gate so that the official records can be updated and a more realistic set of planned discharges developed, based on these field measurements.

Information provided by the individual landholding boundaries (Figure 1) permits an accurate estimation of the total cropped area and the breakdown by crop type. Maps may be laminated in plastic covers to allow the irrigation inspector to take them to the field to monitor actual crop areas instead of relying on guesswork or the reports given by village agricultural officers.

Following the mapping, farmers came to sub-section offices on several occasions to determine the exact size of their landholdings. Because of the current regulations concerning sugar cultivation that require that contiguous areas of blocks be planted to sugar once every three years, landholding boundaries have to be erased and then reestablished once the sugar has been harvested. The maps are seen by many farmers as one way of ensuring their landholding boundaries are properly reestablished by village officials in this process.

Figure 7. Example of a tertiary block map that delineafes landholding boundaries—Block BT2Ka.1, Rentang System.



3.2. MEASURING DISCHARGE AND CALIBRATING STRUCTURES

The implementation of operational plans that are based on the delivery of specific discharges requires a combination of good physical control over water and a set of functioning discharge measurement facilities. Without such measurement and control capability, the management of canal discharges becomes more a matter of personal judgement or guesswork than a systematic allocation of planned volumes of water.

In each of the four systems. an inventory was carried out to assess the current functionality of both control and measurement facilities. Following this stage, a series of calibration measurements were undertaken to increase the ability of field staff to implement the operational plans. The findings of these activities can be summarized as follows:

* Control facilities were not always adequate to effectively implement operational plans.

  On average, only 75 percent of all control structures in the 4 sample systems were functioning sufficiently well to allow proper control over water (Table 4). In one system, less than 50 percent of all structures were operational. The majority of broken or damaged structures were tertiary gates, but there were several cases of secondary and main canal gates that were not functioning properly.

  Main causes of lack of control: Leakage 32%
  Broken spindle 15%
  Broken gate 20%

System	Number of gates	Operational control	
		Number	Percent
Cikeusik	159	139	87
Rentang	79	38	48
Ciwaringing	58	45	78
Ciherang	57	42	74

* Measurement capability was invariably lower than control capability.

  Only 51 percent of all measurement devices were functioning (Table 5). In addition, a further 16 percent of offtakes had no measurement facility installed, making it impossible to measure discharge at over 60 percent of all locations.

System	Number of gates	Measurement possible		Number of gates present
		Number	Percent	
Maneungteung	129	102	79	13
Rentang	56	12	21	2
Ciwaringing	48	18	38	11
Ciherang	41	8	20	18
Total	274	140	51	44

Table 6. Handover conditions between irrigation inspectors' areas—Maneungteung Irrigation System, West Java.

From	To	Location	Gate type	Measurement
Maneungteung Barat (Ciledug)				
Juru 1	Juru 2	MTR 4 Main	Stop logs	Cipoietti
Juru 1	JUN 2	MTR 4 Sec. JTS	Sliding (new)	Cipolett
Juru 2	Juru 3	MTR 5 Main	Sliding (new)	None
Juru 3	Juru 4	PB 1 Main	Sliding (new)	Cipolett
Juru 4	Juru 5	PB 4 Main	Sliding (new)	None
	Juru 6	BLS 3 Main	stop logs	None
Juru 6	Juru 7	BLS 9 Main	Stop logs	None
Juru 6	Juru 7	BLS 11 Main	Sliding (new)	Cipoletti
Juru 7	Juru 6	BLS 10 Main	Sliding (new)	None
Maneungteung Timur (Waled)				
Juru 8	Juru 9	Weir	Sliding	Parshall flume
Juru 9	Juru 10	M 5 Barat	Sliding	Parshall flume
JUN 9	Juru 1	M 5 limur	Sliding	Cipoletti
Juru 10	Juru 11	MB 5 Main	Sliding	None
Juru 11	Juru 12	MB 8 Sec GG	Sliding	Cipolettl
Juru 11	Juru 12	MB 10a Main	stop logs	None

Control facility	Sliding	11	73%
	stop logs	4	27%

Measurement capability	Parshall flume	2	13%
	Cipolett	6	40%
	None	7	47%

Main causes of lack of control:		
	Leakage	23%
	Broken	24%
	No scale	19%

* Effective control or measurement facilities were not always present at the boundaries between adjacent irrigation inspectors' areas.

  Effective control and measurement at the boundary between adjacent irrigation inspectors' areas are needed for proper accountability and coordination of water distribution. In Maneungteung, only 73 percent of handover points between inspectors' areas had effective control structures, and discharge could only be measured at **53** percent of the locations (Table 6).

* Using simple calibration techniques it proved possible to substantially increase measurement capability.

  In the four sample systems, a total of 190 gates **or** measuring devices were calibrated. This raised measurement capability from 40 percent to 93 percent at all locations where discharge measurements were required in order to properly implement the measurement program. This program was undertaken using only field staff from the systems *so* that capability to repeat the program when required would be established.

3.2.1. Utility of the Calibration Program

The primary reason for the calibration activity was to allow proper implementation of the operational plan. Without discharge measurements that record the actual water delivered, systematic implementation of a discharge-based operational plan is 'not possible.

Additional benefits are that the calibration program allows for relatively easy determination of conveyance losses and the implementation of an effective system of monitoring and evaluation of the water delivery plan.

Gate keepers benefit from this program in that they can directly measure discharge through each gate and determine the extent to which they are properly allocating available water into each channel.

Irrigation inspectors benefit directly from this program because they can now determine actual discharges delivered to each gate under their control. They can assess the performance of each gate keeper within their area to ensure that particular gate keepers follow the instructions passed down to them.

Irrigation inspectors can also measure discharges at the boundaries of their area along the main and secondary canal systems and ensure that they both receive and pass on the specified volumes of water. Without this measurement capability, it is impossible for downstream irrigation inspectors to determine whether or not they actually receive their entitlements.

The newly available information can also be used as part of an actual needs-based field assessment where calculated values for tertiary-level water requirements are compared with values based on a relationship between actual discharges and field-level water adequacy. In this, standard calculations of block requirements could themselves be "calibrated" with other measures of crop water adequacy. This can be done in lieu of more expensive methods for measuring other aspects of demand than that of irrigated crop areas (such as seepage and percolation). Of course, crop water adequacy would have to be measured, either qualitatively (through farmers' reactions) or perhaps by observation of crop water stress.

Following implementation of the program, system managers are now in a position to implement an effective monitoring and evaluation of water allocation and delivery. Use of actual field discharge measurements allows them to evaluate whether the planned water delivery pattern was implemented, check whether assumptions on conveyance losses were correct, and then modify the planning estimates in subsequent iterations.

it also allows managers to assess their maintenance priorities and needs. Faced with a situation where a high proportion of gates do not function as intended, the inventory process allows managers to prioritize repairs to reflect the operational requirements. A schedule of priorities, focussing first on main and secondary head gates, then on boundaries between irrigation inspectors' areas and finally at tertiary level, will have the greatest impact on operational implementation and have the cheapest cost per ha.

3.3. MEASURING CONVEYANCE LOSS

The importance of having realistic values of conveyance losses for determination of overall system-level water requirements should not be underestimated. While the design engineer requires some overall estimate in order to properly size canals, the operations staff require more precise values for each canal so that they can be sure of meeting target discharges at each point throughout the conveyance system. From measurements taken in 16 sections of main and secondary canals in the four sample systems in West Java, the following conclusions can be drawn:

* Canals that receive return flows or "supplemental water sources" have to be treated completely differently from those that do not.

  Three of the 16 sections measured have significant return flows, with the result that conveyance loss figures are much lower than normal. Two of the sections measured always had negative conveyance losses, indicating that return flows exceeded losses (Table 7).

Table 7. *Results* of conveyance ***loss*** measurements—Management Information Project, West Java

Sub-section canal	Canal length (km)	Number of gates measured	Average discharge at upper end (l/sec)	Average icharge at ower end (l/sec)	Total nveyance ss (l/sec)	Total conveyance loss (%)	Percent oss per ilometer	Does an imeasured uppletion enter the canal?
. Sukaperna								
ertícala 1 Section	5 747	a	763 40	568 76	194.64	28.91	4.68	No
erticala 2 section	3 205	8	434 40	373 99	60.41	16.38	4.97	No
Total	S 042	16						
Average						21.64	4.83	
!. Leuwimunding								
Varingin Main/Section	0312	17	▮974 84	2,16780	111.05	7.16	0 77	Yes
Iangkapandak Section	2 023	6	19420	250 27	0.00	0.00	O W	Yes
Airat Section	4 769	9	403 65	350 13	53.52	14.19	2 06	No
Valin Section	5 350	19	290 92	189 27	101.65	34.28	6 41	No
Auncang Section	2 023	10	281 30	14992	131.38	43.64	21 67	No
Total	23.48	61						
Average								
Vo Suppletions						30 77	10 35	
Vith Suppletions						358	0 30	
I. Cisangkuy								
Iantap Section	3 227	6	532 63	352.63	180 00	34 32	10.64	No
'anjung Section	0 590	4	233 39	268.08	0 00	OW	0 00	Yes
Total	3.817	12						
I. Maneungteung								
MTR Main Canal	1972		4 494 80	3.788 18	706.62	15.21	7 70	NO
MB Main Canal	8 056		257668	1,856.46	720 22	27.17	3 38	NO
Losari Section	0142		1 787 78	137632	411 48	22.26	2 44	NO
Pabedilan Section	2 744		1 072.20	020 54	15166	13.31	4 88	NO
Jatiseeng Section	2 920		4 w 00	306 10	93 90	22.09	7 58	No
Playangan Section	2 920		382 a2	31374	68 88	17 27	5 92	No
Sumber Section	1391		145.60	127 60	18 00	11 84	8.50	NO
Total	29 45	104						
Average						18 45	5 77	
Overall total	655	103						
Average								
No suppletions						23.01	7.06	
With suppletions						2.39	0.26	

* The standard guidelines for estimation of conveyance losses were too low.

Actual losses were within the range specified in target discharges in only 1 of the 13 sections without return flows. Current procedures apply a standard loss factor, ranging between 7.5 percent and 12.5 percent, average losses, shown by field data for all sections were at 23.0 percent, nearly twice the maximum official estimate.

* Conveyance loss values should be expressed as a function of distance to allow for the effect of varying locations of tertiary blocks along canal sections.

  Currently, all blocks are assigned the same main and secondary loss coefficients, regardless of their relative position along the canals. Field data indicate that actual losses in canals without return flows ranged from 11.8 percent to 43.8 percent (Figures 2a and 2b). Losses per kilometer (km) were generally more uniform, in the range of 3.0 percent to 7.0 percent (Figures 3a and 3b), and they were a more useful set of data for estimating conveyance losses.

* Within each system there is a significant range of conveyance losses between different canals.

  Average losses in Maneungteung System ranged from 2.4 to 8.5 percent per km, or overall losses of 11.8 percent to 27.1 percent for the canal sections measured (Table 8). Similar results were obtained in other systems. These variations relate both to canal conditions and to differences in topography and soils.

* Conveyance loss rates are sensitive to the actual discharge in the canal.

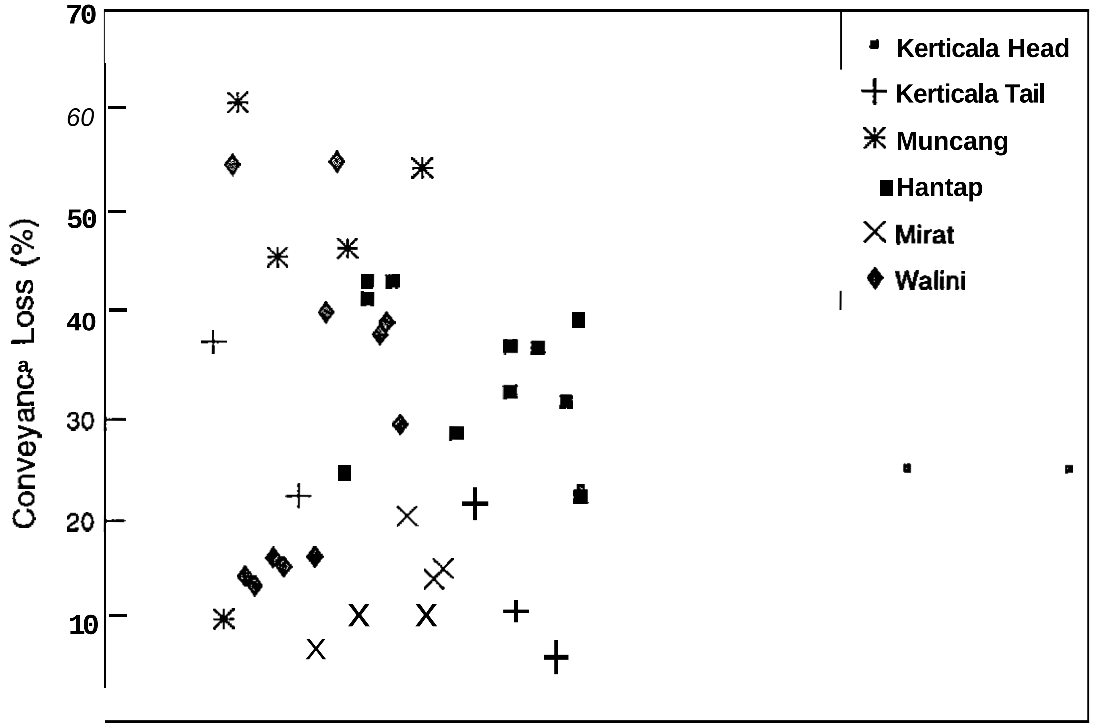
  Overall losses and losses per km both decline as incoming discharge declines. (Figures 2 and 3). This means that dry season conveyance loss factors can be much lower than those used for wet season operations.

3.3.1. Utility of Conveyance Loss Measurements

Operational Planning

It is clear that without actual values of conveyance loss measurements, system managers are not able to properly design a water distribution schedule that can guarantee that target discharges will be met. The current practice of applying a standard coefficient irrespective of canal length, location in the system, soil or topography, means that main and secondary canal discharges and subsequent management are far less realistic than even the calculation of tertiary-level discharge requirements.

Figure 2a. Conveyance losses, Rentang, Ciherang and Ciwaringing—dry seasons I and II, 1989.



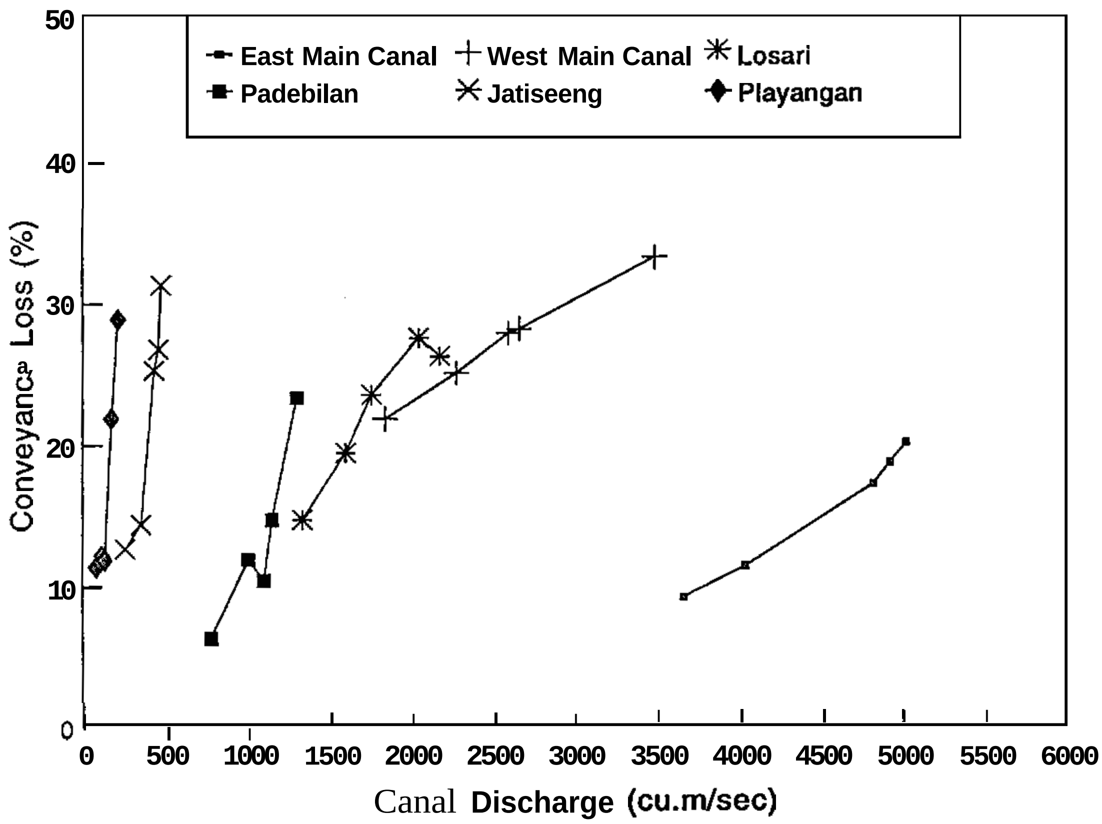
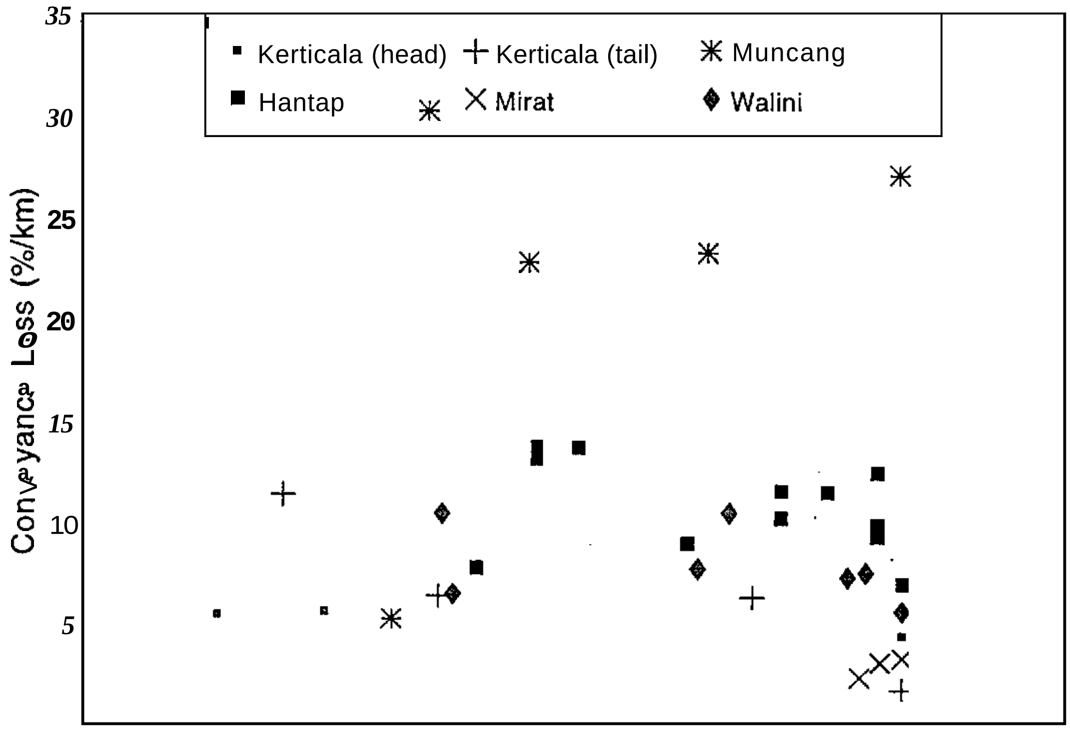


Figure 3a. Conveyance losses per kilometer, Rentang, Ciherang and Ciwaringing—dry seasons I and II, 1989.



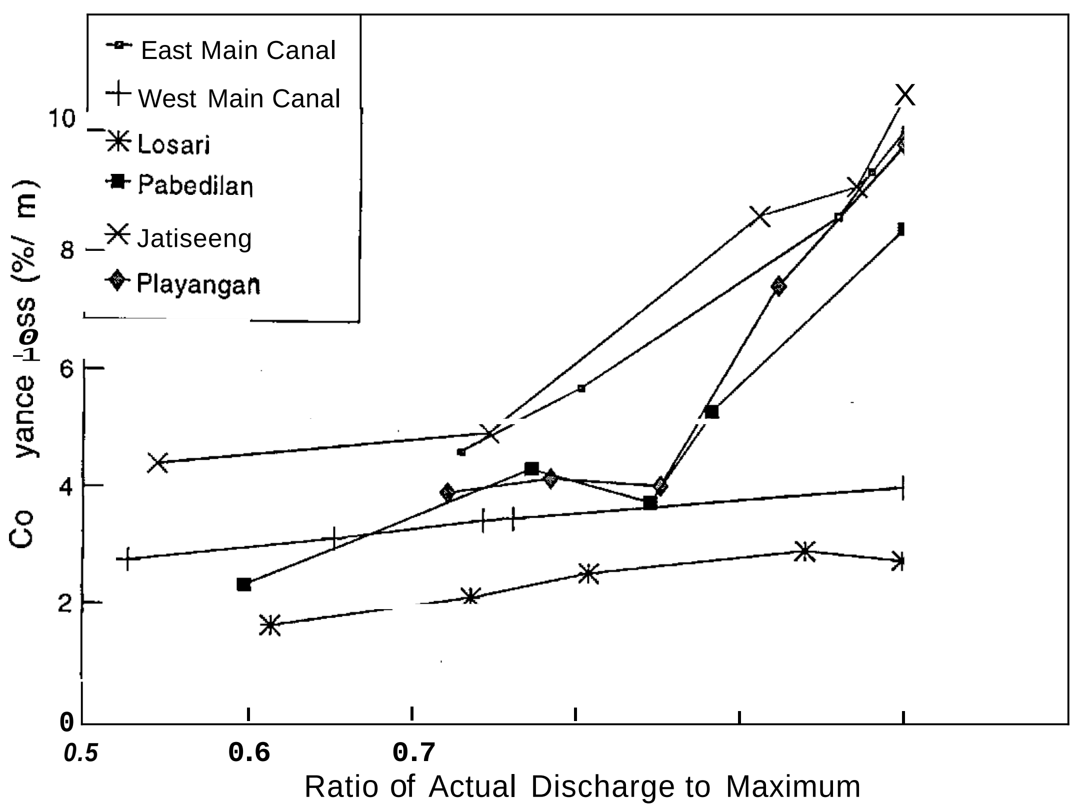


Table 8. Conveyance losses—Maneungteung Irrigation System, West Java

Canal section	Section length (km)	Date	Total inflow (l/sec)	Total outflow (l/sec)	Total loss: Liters per second	Total loss: Percent	Total loss: Percent per km
East Main Canal (BM V to MTR VII)	1.972	24 Apr 89	5,023	4,019	1,004	20.0	10.1
		2 May 89	4,922	4,005	917	18.6	9.4
		17 May 89	4,821	3,998	823	17.1	8.7
		10 Jun 89	4,040	3,583	457	11.3	5.7
		17 Jun 89	3,668	3,335	333	9.1	4.6
West Main Canal	8.056	25 Apr 89	3,494	2,338	1,156	33.1	4.1
		17 May 89	2,664	1,916	748	28.1	3.5
		5 Jun 89	2,599	1.876	723	27.8	3.5
		14 Jun 89	2,282	1,710	571	25.0	3.1
		3 Jul 89	1,845	1,442	403	21.8	2.7
		Average	2,577	1,856	720	27.2	3.4
Losari Secondary	9.142	24 Apr 89	2,179	1,607	571	26.2	2.9
		2 May 89	2,051	1.488	563	27.5	3.0
		17 May 89	1,763	1.348	415	23.5	2.6
		10 Jun 89	1,805	1.294	311	19.4	2.1
		17 Jun 89	1,341	1,145	197	14.7	1.6
		Average	1,788	1,376	411	22.3	2.4
Pabedilan Secondary (PB I to PB III)	2.744	24 Apr 89	1,307	1,003			
		2 May 89	1,155	985			
		17 May 89	1,106	991			
		10 Jun 89	1,010	889		11.9	
						6.3	2.3
		Average	1.072	921		13.3	4.9
Jatiseeng Secondary	2.920	24 Apr 89	479	329	150	31.3	10.7
		2 May 89	465	341	124	26.8	9.2
		17 May 89	437	327		25.3	8.7
		10 Jun 89	358	306		14.4	4.9
		17 Jun 89	261		33	12.7	4.4
Playangan Secondary	2.920	25 Apr 89	446	318	1		
		17 May 89	413	322			
		5 Jun 89	381	335		11.9	
		14 Jun 89	351	308		12.2	
		3 Jul 89	323	286		11.4	3.9
		Average	383	314	[illegible]	17.3	5.9
Sumber Secondary	1.391	25 Apr 89	216	185		14.3	10.3
		17 May 89	174	150	24	13.8	9.9
		5 Jun 89	136	121	15	11.1	7.9
		14 Jun 89	118	107	11	9.4	6.7
		3 Jul 89	84	75	9	10.7	7.7

in cases where losses are higher than expected, it is likely that there will be shortfalls in delivered discharges towards the tail of the system if upstream areas take their full permitted allocation.

Where return flows are present and overall losses are reduced, the opposite will be true: tail-end areas will receive more than their allocated discharge, resulting in a similar pattern of inequity. Under these conditions, operations staff should not allow for any loss in planning of target discharges unless there is field evidence that return flows are not always present.

Planning for Maintenance and Rehabilitation

As system managers gradually build up knowledge of the variation in losses within their systems, they will be able to identify those canals that have the highest losses. In some cases, these will be the result of inadequate maintenance, with gates and canal banks suffering from leaks and other losses. A proper maintenance program aimed at minimizing these types of loses can only be effective when based on the type of data collected in this program.

In other areas, high losses may be the consequence of topographic or soil conditions. In these areas, even with good maintenance, losses will be high and thus these areas would take higher priority if and when resources are made available for selective lining of canal sections.

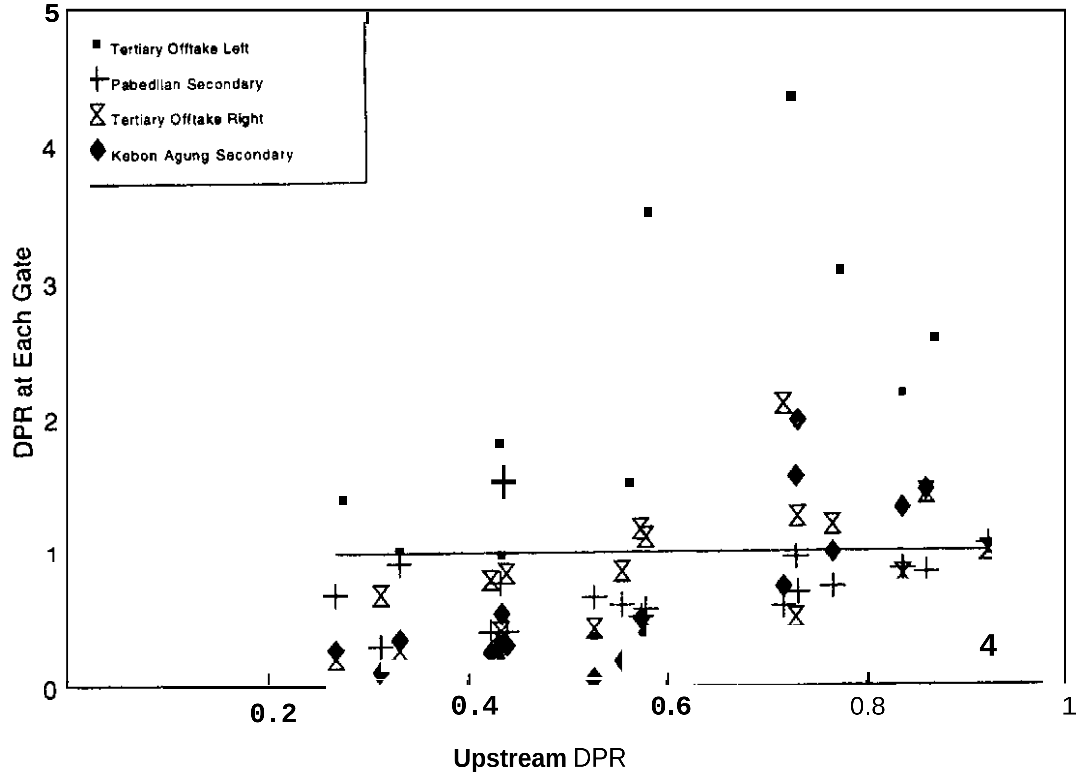
Revision of Operational Guidelines

In the longer term, as data from more systems become available, section- or provincial-level design guidelines can be gradually modified to reflect the actual data available and not use uniform coefficients. System managers can then be provided with conveyance loss estimates based on an assessment of physical conditions until such time as they complete measurement programs in their own systems.

It should be stressed that in the long run, there is no effective substitute for local-level measurement of conveyance losses.

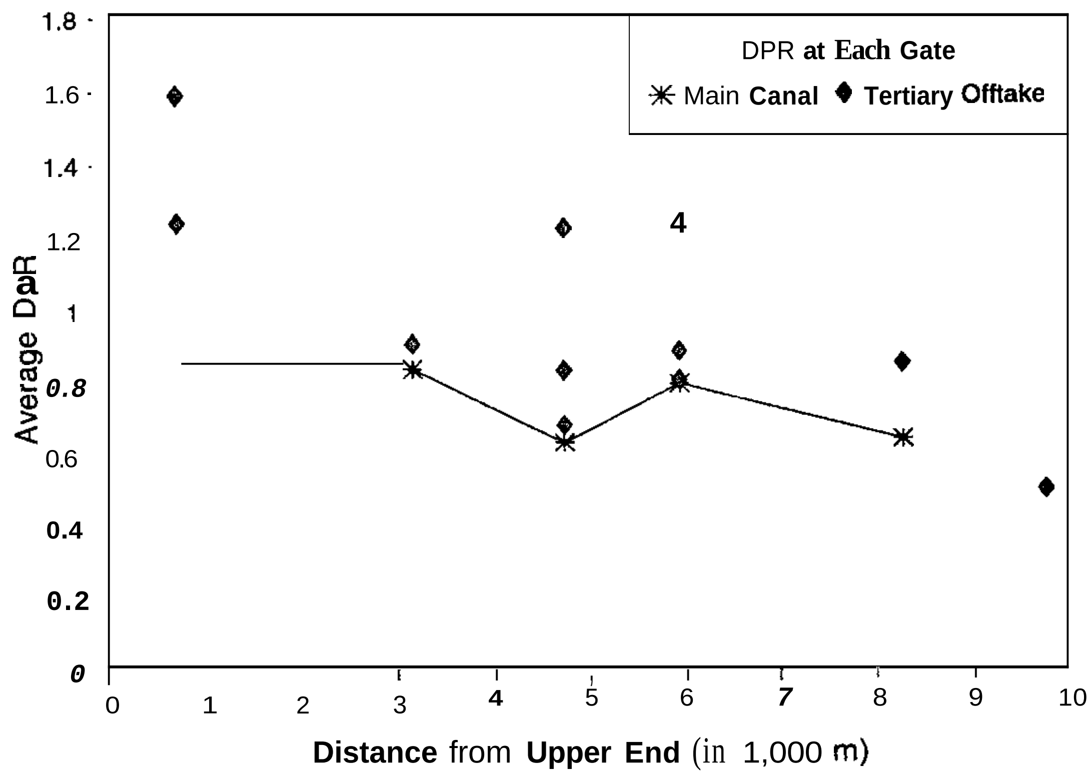
3.4. MONITORING WATER DELIVERY PERFORMANCE

In addition to upgrading the database used in determining water delivery plans, the Project also addressed ways in which monitoring and evaluation of the plan itself could be improved. The mechanism developed for monitoring implementation of the operational plan was the Delivery Performance Ratio (DPR). This ratio compares actual discharge to planned discharge, and can be used at any water measurement location in the system.



Note: DPR = Delivery performance Ratio.

Figure 5. Downstream changes in DPR, Maneungteung Barat, dry season, 1989.



Note: DPR = Delivery Performance Ratio.

Results from Phase I of the IIMI/Public Works Study in East, Central and West Java showed that there were major differences between planned and actual deliveries: in some cases tertiary discharges were getting an average of as much as five or six times what was targeted in the operational plan. There was also substantial evidence that upper-end parts of systems obtained more than their fair share of water at the expense of tail-end areas.

The use of a dimensionless parameter such as DPR allows comparisons to be made of water delivery performance between different channels at the same structure, as well as between DPR at different structures along the same canal. Examples of results of both of these assessments are presented in Figures 4 and 5.

Within the Management Information Project, an additional column was included in the forms used to report planned and actual discharges to show the values of DPR at each location in the system. These data were welcomed both by irrigation inspectors and subsection heads. Officials from the Directorate of lmgation suggested that the DPR could be used best by supervisors. to monitor performance of subordinates as well as identify physical problems.

Comparison of DPR values between Irrigation inspectors' areas allows subsection heads to ensure that water deliveries at system level are as equitable as possible. They can quickly check whether the DPR at the boundary between irrigation inspectors' areas is consistent with DPR at system level, and take the necessary steps to ensure that main system management is consistent with the operational plan.

Irrigation inspectors are able to determine whether water distribution within their area of responsibility is equitable. DPR values that deviate consistently from the plan may indicate either that implementation at that location is not being carried out properly, or that the plan has failed to take into account local variations in water requirements, and that additional data is required to modify the assumptions currently in use in determining target discharges.

3.5. MANAGEMENT INVENTORY FOR WATER USERS ASSOCIATIONS (WUAs)

The most important part of the information on the demand side is that of crop area. This information is supposed to be supplied by the WUA head or village officer for economic and development affairs. It is important that the irrigation inspector has close and frequent contact with the W A . He is supposed to assist in the development of WUAs and in helping them solve their O&M management problems, since these problems have an impact on main system management. The inspector needs information from the WUAs about crop areas, suppletions, soil conditions, drainage problems, crop patterns and planting dates and other O&M problems, which may be as social as they are technical. An active WUA is an important element in strengthening the information management capacity in a system. Furthermore, it is part of the inspectors' role to strengthen the management capacity of WUAs.

A WUA management inventory was conducted by irrigation inspectors for all WUAs in their areas, in the pilot systems. This was an experiment in obtaining a minimum set of information at the PRIS field office level on management needs and capacities of WUAs. It was also meant to help orient the

Inspector to deal with the WUAs in a more functional way (i.e., concerning local O&M problems). There is a tendency among agency staff to emphasize institutional development in a standardized. structural way, such as that all WUAs should have the same type of leadership positions, constitution, water fees, etc., without reference to actual management requirements.

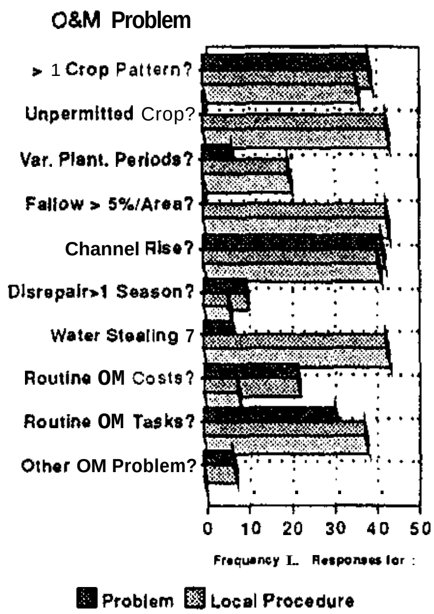
In the survey (Table 9), WUAs were asked about whether or not certain conditions existed locally, which would have a direct effect on management needs. Ten potential types of problem were used as indicators. Each question about an O&M problem [(a) in Table 9] was followed by a question abut whether or not a local procedure or mechanism existed to deal with the problem [(b) in Table 9].

Table 9. *WUA* inventory of *local* management problems and responses.

1	(a) Problem: (b) Response:	Existence of more than one crop pattern in the block WUA/block-level crop pattern regulation.
2	(a) Problem: (b) Response:	Planting of rice three times a year. Sanctions for unpermitted rice planting.
3	(a) Problem: (b) Response:	Variable planting periods. Regulations for planting periods.
4	(a) Problem: (b) Response:	Fallow in more than five percent of the irrigable area Water rotation arrangement.
5	(a) Problem: (b) Response:	Rising level of major tertiary canal in the last five years. Communal desilting work.
6	(a) Problem: (b) Response:	Needed structure in disrepair for longer than one season. Local maintenance plan or arrangement to make repairs.
7	(a) Problem: (b) Response:	Recent water theft. Sanctions against water theft.
8	(a) Problem: (b) Response:	Occurrence of routine local O&M costs. WUA or Mock-level water fee
9	(a) Problem: (b) Response:	Need for local routine O&M tasks done by select persons. WUA officers or functionaries.
10	(a) Problem: (b) Response:	Mher O&M problems. Existence of corresponding local procedures.

Note: WUA = Water Users Association.

Figure 6. Ratio between frequency of WUA, *local* procedure and *O&M* problems — West *Maneungteung, Cikeusik* System, June 1989.



Number of Block With :

Problem	Local Procedure	Ratio LP:P
39	36	0 92
0	26	
7		2.90
62	43	
	41	0.96
10	43	0.60
7		6.14
22	8	0.36
31	38	5.23
7	0	0

Notes: **Average scoring ratios LP/P = 1.68** for **43 tertiary blocks**
WUA = Water Users Association.
O&M = Operation and Maintenance.

This survey was not intended to produce complete or research-quality findings, but intended more as an exercise to help reorient the way irrigation inspectors think and act toward WAs. However, it should produce useful information which would enable the inspector and sub-section head to identify which kinds of O&M problems exist in which blocks and which blocks should be given priority attention for WUA assistance. The ratio of the frequency of local procedures to problems enables the sub-section head to identify which blocks have the most need for assistance, based not on standard institutional specifications but on actual local management needs.

Figure 6 shows aggregate data from the W A management inventory. The frequency of occurrence of each of the ten problems and related local procedures is listed and a ratio of frequency of procedures to problems is displayed for each type of problem. The data is from 118 tertiary blocks in the Maneungteung System of the Cirebon Section, as divided into the west and east divisions. In the west division, where water is generally more adequate and sugarcane is planted extensively, variable crop patterns are more common. In the east division, water theft and structural disrepair were problems more commonly reported than in the west division. Both divisions have extensive siltation of major tertiary canals and the need for varying O&M tasks. The mapping of such features could be a useful planning or evaluation tool.

3.6. REGIONAL SURVEY OF INFRASTRUCTURE AND PROCEDURES

The final activity associated with the Management Information Project aimed at determining the general management information potential of all agency systems in one of the largest sections in the West Java Provincial Irrigation Service (PRIS), the Cirebon Section.

Table 10 presents data from a survey of information management capacity of all 53 PRIS systems in the Cirebon Section in West Java. All but five of the systems had at least one system-level PRIS staff assigned to them. Forty (75%) of the systems were classified as technical, meaning that water can be controlled and measured at the offtake and along the main distribution canals. However, only 28 percent of the systems were implementing the full set of current PRIS O&M forms, and 21 percent were using only forms 01 and 02 (related to crop area and irrigation requirements). Fifty one percent of all systems did not use any forms.

Table 10. *Survey* data related to *management* information capacity—Cirebon *Section, West* Java.

	Frequency	Percent	Area (ha)	Percent
Total number of systems	53	100	44.837	100
Technical systems	40	75	40.232	89
Semi-technical systems	8	15	2,064	5
Simple systems	5	9	2.541	6
Total number of intakes	96	-		
Systems >1 intake	24	45	23,052	51
Total number of suppletions	55	-		-
Number of systems with suppletions	23	43	23,654	53
Number of systems using O&M forms	15	28	28,835	64
Number of systems using forms 01 and 0 2	11	21	6,305	14
Number of systems not using O&M forms	27	51	9.697	22

A major reason for a lack of reporting and using of such Information is that 45 percent of the systems have multiple intakes (many without measurement devices), and 43 percent have suppletions (almost always without measurement devices). There are field-level difficulties for implementlng the current O&M procedures and filling in forms designed for a single-intake system with a measurement device. These difficulties may increase as attempts are made to implement the newer, more elaborate set of forms In different provinces, under the Efficient O&M Program.

There also may be cost and time limitations at the sub-section and section levels for supplying and processing more forms and information than are already done. The constraints for using the current forms most commonly mentioned by staff were that the forms often arrive late. Inspectors (*juru* pengairan) and sub-section staff (ranting *dinas*) tend to fill in and submit the forms to superiors on time, if they have them, because this tends to be a key job performance criterion.

From the perspective of the section chief, the lack of information on how much water is required for each system is of considerable importance for the task of allocating water between irrigation systems served by a single river. Without such information, and the subsequent monitoring of water allocation, it is likely that there will continue to be a high variability in cropping intensities between different systems along the same river. This is certainly the case along the Cisanggarung River (Table 11).

Table 11. Annual cropping *intensities—Cisanggarung* River, West Java.

System	Season	Rice		Nonrice		Sugar		Annual cropping intensity
		Area (ha)	Percent	Area (ha)	Percent	Area (ha)	Percent	
Kuninigan (517 ha)	Wet season	517	100	0	0	0	0	
	Dry season I	501	97	16	3	0	0	
	Dry season II	0	0	134	26	0	0	226
Cipikul (436 ha)	Wet season	436	100	0	0	0	0	
	Dry season I	436	100	0	0	0	0	
	Dry season II	20	5	223	51	0	0	256
Bantarwangi (535 ha)		523	98	0	0	12	2	
	Dry season I	328	61	195	36	12	2	
	Dry season II	0	0	397	74	12	2	276
Citanggulan (873 ha)	Wet season	856	98	0	0	17	2	
	Dry season I	856	98	0	0	17	2	
	Dry season II	65	7	702	80	17	2	290
Ciparigi (295 ha)	Wet season	295	100	0	0	0	0	
	Dry season I	295	100	0	0	0	0	
	Dry season II	182	62	104	35	0	0	297
Maneungteung (7,611 ha)	Wet season	3,862	51	1,076	14	2,152	28	
	Dry season I	863	11	2,330	31	2,059	27	
	Dry season II	13	0	1.561	21	2,279	30	213

4. Methods Employed in the Management Information Project

The Management Information Project (MIP) activity attempted to provide a reasonably accurate set of information for the most important components of operations information. The three major technical methods used were calibrating tertiary offtake structures—for the supply component, and measuring conveyance losses and mapping tertiary blocks—for the demand component.

4.1. MAPPING TERTIARY BLOCKS

Earlier work conducted by IIMI had determined that the most cost-effective method of mapping was using 30-meter (m) long measuring tapes. Although the accuracy was somewhat lower than using cadastral surveying techniques, the cost was significantly lower. Although there had been some desire that the revised maps be used for the calculation of land taxes and the proposed irrigation service fee, it was agreed in the end that the mapping should be solely for use in operational planning.

Mapping was conducted using triangulation. The length of each side of every landholding was measured, together with diagonal distances between opposite corners of each landholding. Irregularly shaped areas were subdivided into more convenient shapes. During mapping, bamboo poles were used to delimit the comers of each landholding.

On average, each mapping team had four members, normally consisting of: (1) the irrigation inspector or staff of the subsection office, who recorded measurements and made sketches; (2) another PRIS staff person, normally an irrigation inspector, who made measurements with the measuring tape; (3) a village official. who identified landholding boundaries; and (4) a villager who held a bamboo pole and the end of the measuring tape.

4.2. CALIBRATING STRUCTURES

Four methods were used for the calibrations: (1) a portable broad-crested weir; (2) existing, functioning measurement devices to calibrate with a staff gauge below the structure: (3) a float device where the canal condition did not permit use of the portable weir; and (4) a Thomson weir In two cases where there was sufficient drop and small canals.

4.2.1. Portable **Broad-Crested** Weir

Out of a total of 190 structures calibrated in the four locations, 156 or 82 percent were appropriate for calibration using a portable broad-crested weir of two sizes-with crest widths of 40 centimeters (cm) and 60 cm. The weirs were 2 m long and made with a 2-millimeter (mm) steel plate (Figure 7). The necessary conditions for use of this instrument are that the canal design capacity is not too small to accommodate the weir and the water buildup caused by the weir. The canal should not exceed 1 m in width, as this is the total width of the weir. There must be a straight stretch of canal of at least 4-to-5 m below the offtake structure and again below where the weir is temporarily installed, with uniform waterflow.

After waterflow out of the offtake is temporarily stopped, the weir is installed in the canal approximately 4-to-6 m below the structure, or lower if need be, where the flow is straight and not turbulent. Earth and twigs are packed tightly around and below the weir and care is taken to ensure all water flowing down the canal goes through the weir. The staff gauge is placed a few meters downstream from the weir, preferably where there is concrete canal lining, with the zero on the scale at the base of the canal, or where discharge will be zero. The offtake gate is adjusted in increments, Measurements are made at the weir and canal staff gauge afler stability is reached at each new discharge level. Weir and canal staff gauge readings and discharge levels are recorded. Afterward, staff at the sub-section or section level, who have the necessary skills, make one chart and table per structure calibrated, showing the relationship between height readings on the canal staff gauge and discharge levels in liters per second (l/sec). Examples of output are provided in Table 12 and Figure 8.

Figure 7. Illustration of portable broad-crested weir

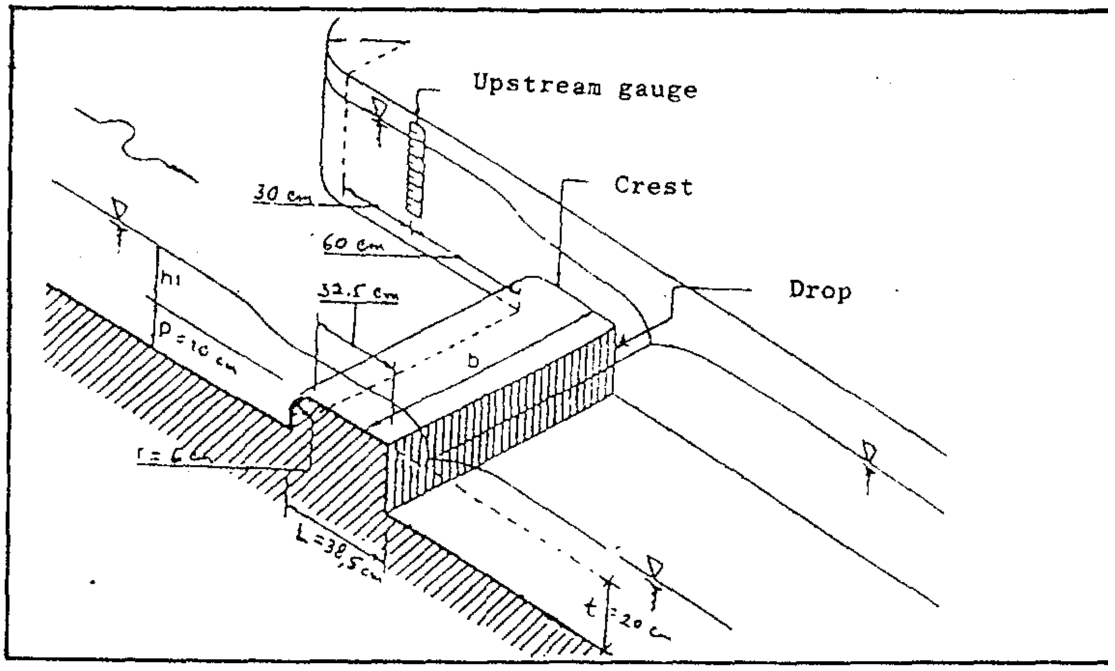


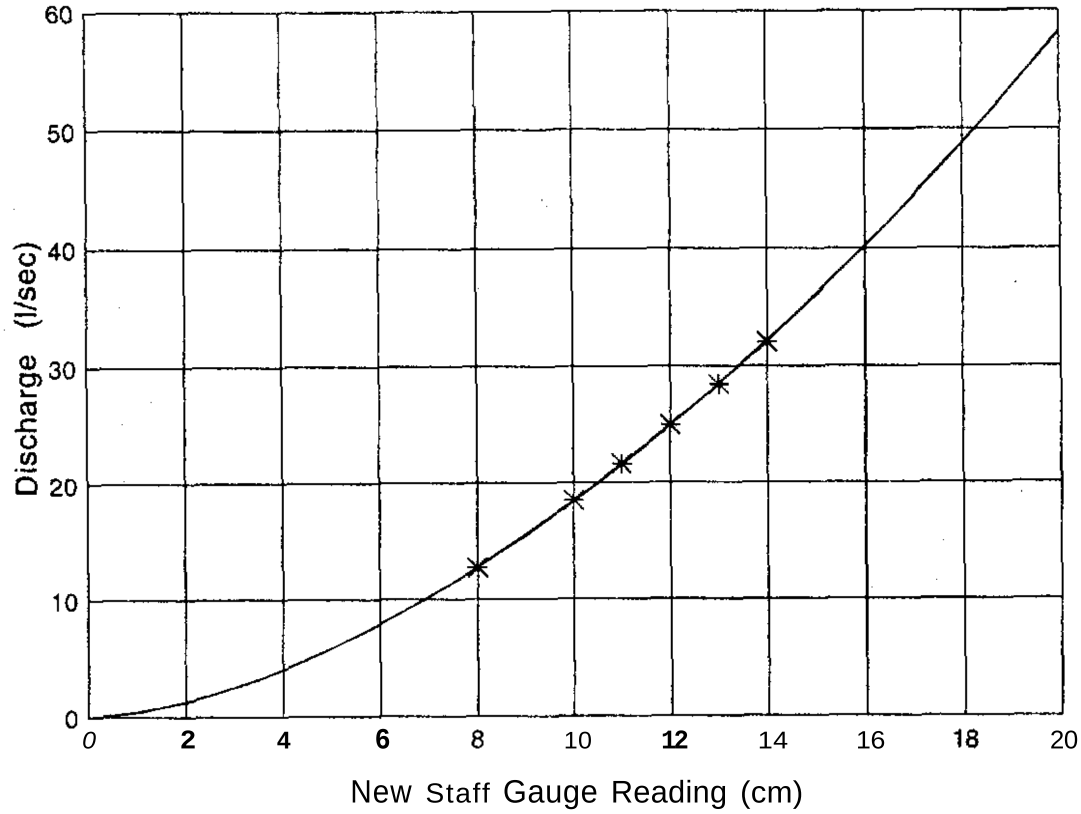
Table 12. Example of calibration data record and discharge table, Block Kr.7.1, Rentang System, Sukaperna Sub-section.

H (cm) Portable broad-crested weir	H (cm) New staff gauge	H (cm) Old staff gauge	Q (l/sec) Before calibration	Q (l/sec) After calibration	LOG (H) New staff gauge	LOG (Q) After calibration
7	8			12.67	0.90	1.10
9	10			16.47	1.00	1.27
10	11			21.63	1.04	1.34
11	12			24.95	1.08	1.39
12	13.			26.43	1.11	0.45
13	14			32.06	1.15	1.51

H (cm) New staff gauge	Q (l/sec)	H (cm) New staff gauge	Q (l/sec)	H (om) New staff gauge	Q (l/sec)
0.00	C.00	5.w	5.64	10.00	16.43
0.25	C.04	5.25	6.34	10.25	19.20
0.50	C.13	5.50	6.84	10.50	19.99
0.75	C.25	5.75	7.37	10.75	20.78
1.00	0.41	6.00	7.90	11.00	21.59
1.25	0.59	6.25	6.46	11.25	22.41
1.50	0.80	6.50	9.03	11.50	23.24
1.75	1.03'	6.75	9.61	11.75	24.06
2.00	1.26	7.00	10.20	12.00	24.94
2.25	1.56	7.25	10.82	12.25	25.61
2.50	1.85	7.50	11.44	12.50	26.69
2.75	2.1'7	7.75	12.08	12.75	27.56
3.00	2.51	8.00	12.73	13.00	28.48
3.25	2.86	8.25	13.40	13.25	29.39
3.50	3.24	8.50	14.08	13.50	30.32
3.75	3.63	8.75	14.77	13.75	31.26
4.00	4.04	9.00	15.48	14.00	32.20
4.25	4.46	'9.25	16.20	14.25	33.16
4.50	4.91	9.50	16.93	14.50	34.13
4.75	5.37	9.75	17.68	14.75	35.12

Note: Discharge equation = Q = 0.403406 *(h+/-0.007664)^1.659309

Figure 8. *Example* of revised rating *curve,* Block *Kr. 7.1,* Rentang System.



4.2.2. Existing Functional Measurement Device

The most common type of gate in West Java is the "romijn gate." This is a vertically adjustable broad-crested weir where water flows over the top of a horizontal plate. The height of the plate can be adjusted to compensate for changes in upstream water level. In many cases, however, the plate is raised above the water level *so* that water passes underneath and cannot be measured. This happens most frequently during the dry season when measurement is most important. Even where the gate appeared to be functioning correctly and where both staff gauges were still present, it was agreed to recalibrate the gate by making discharge readings at a downstream staff gauge in order to verify existing rating information. It was also done in order to separate the measurement structure (new staff gauge) from the control structure, since the latter is *so* often raised to prevent measurement. This method was used for 26 of the 190 structures.

4.2.3. **Float** Device

Calibration using simple float devices was done for six of the structures where the above-mentioned canal design or embankment height parameters did not exist. Although the accuracy of this method is probably no better than ± 15 percent, it was considered better than no calibration.

4.2.4. Thornson Weir

'The Thomson weir was used on two occasions where the canals were quite small and where sufficient head drop existed.

The portable broad-crested weir proved to be highly adaptable. Only two sizes of the weir were appropriate for 82 percent of the offtake structures, which generally served between 30 and 130 ha each. However, field teams reported two problems with the portable broad-crested weir. The first was that it was heavy and difficult to transport and install. Field staff recommended that a smaller type of measuring device be identified and used if possible. The second was that it should be constructed to be a bit more sturdy *so* as to not lose its rigidity afler repeated use. Although the two suggestions may be a bit incompatible, clearly further work, possibly involving field experiments, needs to be done to identify other types of devices, which may be smaller or lighter in weight. such as the use of fiberglass or smaller devices such as cutthroat flumes, etc.

Several of the staff gauges disappeared or were damaged soon following installation. More permanent or expensive materials would be even more likely to disappear. Hence, it is suggested that cheaper and commonly-availabie' materials which are sturdy be used, such as bamboo, instead of the metal plates used. It may be necessary to install or extend canal lining to provide a stable base for the staff gauge. Furthermore, permanent markings should be etched into lining or adjacent large rocks or trees as stable reference poinls to be used if the staff gauge disappears and needs to be reinstalled, *so* that calibration will not need to be repeated.

4.3. MEASURING CONVEYANCE LOSS

Repeated measurements of conveyance losses were made in 16 secondary and main canals in the Sukaperna, Leuwimunding, Cisangkuy, Ciledug, and Babakan sub-sections. This was a total of 65.5 km of canal length. After necessary calibrations were done along the secondary and main canals within the selected systems in each of the sub-sections, the measurement devices at each of the offlakes became the means for estimating conveyance losses along the canals.

The method used was to identify sections of canals where the total discharge entering at the top was measurable, as were discharges at all offlakes and through a lower-end cross-regulating structure (where there was one) along the section of the canal being measured. This enabled a comparison of total flow in and out of the canal section. The difference was the conveyance **loss.**

The purpose behind using this methodology was intended to replicate as far as possible, normal operating conditions over a sufficiently long stretch of canal to be representative of actual loss values. It was not intended that the method be an exact determination of losses over a sample reach, but to calibrate the actual losses involved in regular operations. For this reason ponding methods were not adopted. Further, it was decided not to employ current metering between two calibrated sections, but to make maximum use of the data obtained from the associated activity of calibration of existing gates and measuring devices.

There is another aspect of "realism" to this approach, which is that the effect of unmeasurable suppletions into or out of the canal section being measured be included in the total "**loss**" estimates (although its effects cannot be distinguished from actual **loss** due to conveyance through the canal). Using the method used in the **MIP** then, in many canals in environments such as are common in Java, Bali, and parts of the outer islands, conveyance "losses" may be negative due to suppletions entering the canal. Hence what is really being measured are "Conveyance requirements", which may have additive effects on discharges.

To ensure that allowance was made for any fluctuation in discharge during any given measurement, a float device (a weighted bottle or stick with a weight **on** one end) was placed in the center **of** the canal at the time when the upstream discharge was measured. One person was assigned to follow the float down the canal, recording the travel time between structures and checking to see **if** there are significant flow obstructions along the canal. Measurement teams were waiting at each division structure as needed, ready to measure discharge through all offtakes at that structure, as the float and the person following the float along the side of the canal, reached the structure.

The total amount flowing out of the structures is subtracted from the amount coming in at the top. On a given day **of** observation. three repetitions of measurements were made at 30-minute intervals. This was repeated a minimum of five times during the dry season and five more times during the wet season, to develop separate rating curves and tables for wet and dry seasons.

5. Costs of Implementation

Given the tight O&M budgets faced by Provincial irrigation Service(s) (PRIS), detailed records were kept of the actual costs associated with each component of the Management Information Project. In practical terms, cost feasibility is as important to the PRIS as is technical feasibility.

In keeping these records, costs were divided into field labor costs, office labor costs and equipment. Information was also collected on actual labor inputs. In the training, as far as possible, staff of the PRIS were not paid additional money where it was considered part of their regular job. In some cases field allowances for meals were paid for those whose duties did not normally involve such travel. Some office staff were paid modest honoraria for undertaking additional drawing or calculation work. Farmers were reimbursed when they felt they could not contribute their labor free of charge. However, if WUAs can be convinced of the benefits of the program to them, it might be possible to reduce costs for field labor.

5.1. MAPPING TERTIARY BLOCKS

Mapping teams measured an average of 4.2 ha per day, with an average field progress rate of 1.3 man-days per hectare (Table 13). Areas with smaller average landholding sizes take longer to map, such as in Leuwimunding. Leuwimunding and Ciledug/Babakan had the lowest number of hectares measured per day because they used only four persons per team. The other two locations used a 7-person team, as they preferred to work together in larger groups while they were still learning.

Table 13. Labor and cosf requirements for mapping activity–Management Information Project, West

Sub-section	Number of blocks mapped	Total hectares mapped	Rate of progress (ha/day)	Man-days per hectare	Field labor cost (Rp/ha)	Office labor cost (Rp/ha)	Total cost (excluding materials) (Rp/ha)	Total cost (including materials) (Rp/ha)
Rentang	5	130.20	5.4	1.3	3.779	2.442	6,221	8,756
Leuwimunding	6	296.63	3.0	1.3	3.469	3.155	6.624	8,829
Cisangkuy	1	78.51	4 4	1.6	4.471	2,866	7.337	10.355
Maneungteung	21	982.23	3.9	1.0	2,672	1,393	4,065	5,400
Total	33	1.488						
Average				1.3	3.598 US$2.03	2,464 US$1.39	6,062 uss3.42	8.335 US$4.70

Note: US$1.00 = approximately Rp 1,774 in 1989.

Field labor costs for the mapping exercise were only Rp 3,598 per ha(US$2.03/ha). The total labor cost excluding materials was Rp 6,062 per ha or (US$3.42/ha). The total cost per ha including materials was Rp 8.335 (US$4.70/ha). If it is assumed that measuring tapes can be used to map 15 blocks each (before total deterioration) it would drop the total cost per hectare with materials and equipment to Rp 8,119.8 (or US$4.57/ha). These costs, as with the costs for calibrating and conveyance, are for direct field operational costs and exclude costs of training and supervision.

5.2 CALIBRATING STRUCTURES

Each calibration team on the average consisted of five members, one for adjusting the gate (usually the PRIS gate keeper), one or two for reading the weir and canal staff gauge readings (one of which was the irrigation inspector), and two local people for carrying and installing the portable weir (if used). Table 14 displays data on labor and cost requirements for calibration. The calibration teams did an average of 2 9 structures per day. With an average team size of five, the **field labor** requirement for the calibrations was roughly 2.0 man-days per structure. Field workers were paid local rates for field work. Calibration rating curves and tables were made in the subsection or section offices by staff with the appropriate skills. Office staff were paid normal modest typical fees for such non-routine activities.

Table *14.* Labor and **cost** requirements lor *simplified* calibration *methods—Cirebon* Section, West Java.

Sub-section	Number of gates calibrated	Type of calibration used				Average number of gates calibrated	Field man-days per structure	Labor cost per structure (Rp)		Cost per structure including equipment (Rp)
		Romijn Gate	Portable weir	Float device	Thomson Weir			Field	Office	
Rentang	60	-	58	2	-	3.3	1.7	4,625	2,167	16,565
Leuwimunding	44	13	25	4	2	4.0	1.6	4,557	1,773	17,295
Cisangkuy	28	-	28	-	-	2.3	2.2	6,214	2,321	20,864
Maneungteung	58	13	45	-	-	2.1	2.4	6,517	1,724	24,045
Total	190	26	156	6	2	-	8			
Average						2.9	1.98	5,478 US$3.09	1,996 US$1.12	20,192 US$11.38

Note: USt1.W = approximately Rp 1,774 in 1989.

The average field labor cost per structure was Rp 5,478 (US$3.09), while office labor costs per structure were US$1 12. If PRIS were to implement such calibration work as a routine program, it is possible that a decision could be made to lower or discontinue some of the pay rates to PRIS staff, particularly for office work Two portable weirs were allocated lo each sub-section, with the cost of each weir being Rp 100,000 (US$56). Including the cost of the portable weirs, staff gauges, and other materials for installation and recording, the total average cost per structure was Rp 20,192 (US$11.38). Since the weirs are sturdy enough to be used for several more calibrations, this total average cost per structure could be expected to decline to near about half this amount over time. It was not possible to derive separate costs for the different methods because labor was paid by the day and often, two or three different structures were calibrated in a day using different methods by the same team.

Data on costs per ha again demonstrate the benefits from a prioritized program (Table 15). Examples from Maneungteung and Ciwaringing show that if calibration is focussed at main- and secondary-channel level only, costs are quite modest (Rp 10/ha/year or US$0.01/ha/year). A program designed to match up with the boundaries of all irrigation inspectors increases the cost slightly to Rp 69 per ha per year (US$0.04), but has significant implications for monitoring of systemwide water distribution. Calibration of tertiary gates, however, increases costs substantially to around Rp 345 per ha per year (US$0.19/ha/year). Full cost effectiveness is therefore likely to be obtained by a phased implementation that starts with calibrations at main and secondary head gates, plus gates at the boundaries of irrigation inspectors, and gradually includes tertiary gates as time and money permit.

Table 15. Costs of calibration program—Cirebon Section, West Java.

Alternative calibration strategies	Number of gates	Total estimated cost (Rp/ha)	Total estimated cost (Rp/ha/year)	Total estimated cost (US$/ha/year)
Maneungteung (7,611 ha)				
Main canal only	3	14	10	0.01
Main and secondary canals	16	74	53	0.03
Main and secondary canals plus irrigation inspector boundaries	21	97	69	0.04
All gates	130	507	345	0.19
Ciwaringing (2,386 ha)				
Main canal	1	15	10	0.01
Main and secondary canals	6	88	63	0.04
All gates	37	356	246	0.14

Costs used in calculations	Main and secondary gates—estimated (Rp)	Tertiary gates—actual (Rp)	
		Maneungteung	Clwaringing
Average field cost per slruciure	13,000	6,517	4,557
Average office cost per structure	2,000	1,724	1,773
Average equipment cost per structure		15,804	10,965
Total cost per structure	35,000	24.045	17,295
Total cost per structure per year	25,000	16,143	11,812

Note. Assuming 2-year life length of equipment.
US$1.00 = approximately Rp 1,774 in 1989.

5.3. MEASURING CONVEYANCE LOSS

The average field cost of measuring losses was Rp 927.75 per observation (US$0.52) or Rp 16,970.5 (US$9.56) per season, assuming 15 observation repetitions (Table 16). This method for estimating conveyance losses requires a relatively large staff, with at least one recorder for every three gates. Each division structure must have at least one recorder ready to make discharge readings as the float and walking irrigation inspector pass by. Given the limited canal length measured during the MIP activity, the effect of equipment and material costs on total cost per km of canal is high.

Total costs including equipment and material are estimated at Rp 53,235 (US$30.00) per km of canal length for two seasons of measurement (20 total observations). It is recommended to develop a loss rating curve for rainy and dry seasons, since the loss rates will be different for each season. At least five sets of observations per season are made which is a minimum for deriving a rating curve. However, repeating measurements are not needed every season.

Although the costs per km appear high, when transformed into costs per ha benefitted, a different image emerges. The data from Maneungteung (Table 17) clearly indicate that priority should be given to main canals, where the cost of conveyance loss measurement is approximately Rp 110 per ha (US$0.06/ha). A more ambitious program that includes major secondary canals increases costs to Rp 281 per ha (US$0.16/ha), while a full measurement program of all secondaries results in a cost of Rp 410 per ha (US$0.23/ha). These costs compare favorably with current annual O&M allocations of about Rp 12,000 per ha (±US$6.75/ha) and with a standard desired funding level of Rp 25,000 per ha (±US$14/ha). However, calibration of gates is required before the conveyance loss measurements can be conducted properly.

Table 16. Labor and cost requirements, conveyance loss measurements—sample systems in West Java.

Sub-section	Number of measurements			Man-days per km	Total cost of materials used (Rp/km)	Seasonal cost per kilometer			Annual cost * (Rp/km)
	Canals	Gates	Kilometers			Field labor (Rp/km)	Office labor (Rp/km)	Total labor (Rp/km)	
Rentang	2	16	9.0	3.9	22,788	11,336	1,770	13,106	33,808
Leuwimunding	5	61	23.5	3.9	48,949	10,372	1,704	12,076	40,468
Cisangkuy	2	12	3.8	5.5	21,128	14,671	4,192	18,863	44,769
Maneungteung	7	104	29.2	8.4	138,662	21,670	2,167	23,837	93,895
Total	16	193	65.5						
Average				5.4	57,882	14,512 US$8.18	2,458 US$1.38	16,971 US$9.56	53,235 us129 99

* Total annual costs assume 10 readings per year and an equipment life length of 3 years
Note: US$1.00 = approximately Rp 1,774 in 1989.

Table 17. Costs of conveyance loss program—Cirebon Section, West Java.

Alternative strategies for measurement program	Total length of canals (m)	Total estimated cost (Rp/ha/year)	Total estimated cost (US$/ha/year)
Maneungteung (7,611 ha)			
Main canal only (below MV)	15,423	110	0.06
All main canals	25,825	181	0.10
Main and major secondary canals	40,141	281	0.16
all main and secondary canals	58,634	410	0.23

Note: Annual cost assumes 3-year measurement cycle.
US161.00 = approximately Rp 1,774 in 1989.

5.4. WUA INVENTORY AND REGIONAL SURVEY

These activities were undertaken as regular duties of irrigation inspectors and sub-section chiefs. Thus no additional costs were incurred in generating this information.

It was not possible to evaluate the impact on management of the Management information Project within the time frame of this study. It is hoped that this may be done in the future.

6. Conclusion

The major benefits of the above approach for improving information for irrigation system management are summarized below:

* Improved implementation of operational plans.

  With better information available on actual irrigated areas, conveyance losses and the condition of physical facilities for water control and measurement, system managers can more effectively develop and implement operational plans.

* Water delivery performance monitoring.

  Better information on delivered discharges. and their comparison with target discharges through use of the Delivery Performance Ratio, facilitate the development of a systematic monitoring program of short-term water delivery performance. This monitoring can be used by all levels of PRIS staff up to the section head.

* Improved evaluation of operational plans.

  Improved interaction with WUAs, including mapping and field investiiations by irrigation inspectors, enables standardized water allocations to be modified in the light of assessing crop water adequacy and actual irrigable areas. This enables local differences in demand to be accommodated into the overall system-level plan rather than leaving it solely up to the discretion of irrigation inspectors to make informal adjustments to the plan.

* Maintenance planning.

  The Management Information Project (MIP) establishes an ongoing mechanism for monitoring the functionality of control and measurement structures. This helps forward planning of budgets and supports a needs-based approach to maintenance and repair budgets. It links justification for repairs to operational needs.

* Improved job satisfaction.

  Many of those involved in the MIP reported favorably on the practical value of the information obtained and the new skills gained. PRIS sections not included in the activity have asked to be included or to be given training and equipment so that they can do the activities on their own. Field-level PRIS staff have expressed job satisfaction with work which was interesting and increased their understanding. Some have said that now they do not have to keep operating from fictitious or assumptive information.

The approach was also designed to be relatively simple to implement. There is no great value in redesigning the technical component of information management if it is not within normal management capability to implement and sustain. The following advantages should be stressed:

* Use of existing staff.

All field activities were undertaken using local staff of the Provincial Irrigation Service (many of whom had only high school technical degrees). They were assisted where necessary by local farmers and village leaders. Once initiil training has been completed, the knowledge of how to repeat any component of the program is not lost. Office support, notably calculations and drawing of maps and rating curves, was provided by local PRIS staff. Training was provided by provincial- and section-level staff, so that they would be able to assist in future dissemination of the program into neighboring systems, and eventually throughout the province.

* Implementation of each component can be undertaken separately.

Although the long-term objective is to improve all components of the information base, each component can be undertaken in isolation if overall financial resources are not available. This incremental approach has the further advantage that other routine activities are not disrupted while upgrading the information base. Mapping is best done between seasons or during fallow periods, when it is easier to move about the fields and identify farm boundaries.

* Avoidance of special project mentality.

The intention of the pilot project was for the activities to become part of the routine O&M program in the provinces. Rather than attempting to overcome all the information constraints in a single intensive effort, the procedures can be gradually undertaken over a period of two or thee years, depending on available budgets. Occasional updatlng of information will be needed every few years depending on local conditions.

* The majority of activities are relatively low-cost.

In most cases, it should be possible to phase the implementation of activities as needed due to limited routine O&M budgets and not have lo wait for special project allocations before implementation can be started. Items such as portable weirs and measuring tapes can be shared at section level, thereby further reducing the modest capital investment required.

Based on the experiences of the four sub-sections in which the MIP activity was conducted, it is clear that both field staff and supervisors see it as a practical approach to overcoming the difficulties of managing systems where the database is inadequate. The ready acceptance of this program, and the desire of other sections to be included, indicate a strong potential for widespread adoption.

Reference

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Appendix 1

THE FACTOR-K SYSTEM OF WATER ALLOCATION IN WEST JAVA

The basic principle of water allocation throughout publicly managed irrigation systems in Indonesia is a modified demand-based system, traditionally called *pasten* or "sharing." Water allocations are based on an assessment of actual field-level demand in each tertiary block. When water supply at the head of the system is adequate to meet the cumulated demand from all tertiary blocks, including allowances for conveyance losses along main and secondary canals, planned discharges reflect the actual demand. Up to a certain limit, this process means that tertiary blocks that have been planted with a higher proportion of high water demanding crops will get a larger share of water than those planted to less water demanding crops.

There are two basic exceptions to this demand-based procedure. The total area planted to rice in any tertiary block is determined through an annual planning process, and any rice planted in excess of this limit should be counted as a less water demanding crop. This procedure has been adopted to try to limit the potentially inequitable consequences of one group of farmers consistently planting all of their area to rice, and thus obtaining a disproportionate share of total water resources.

The second exception comes when water supplies at the head of the system are insufficient to meet total projected demand for water. Under these conditions the total demand for each tertiary block is multiplied by a coefficient that represents the ratio of supply to demand at the system head. This coefficient is known as "Factor-K." As long as Factor-K is between about 0.7 and 1.0, discharges to each tertiary block are reduced by the same amount. If they so desire, rotations between farmers or groups of tarmers within the tertiary block may be organized. With lower values of Factor-K, rotational irrigation has to he introduced between tertiaries in order to maintain adequate stream sizes into each block. When Factor-K falls below about 0.4, then rotations have to be introduced between secondary canals to maintain the hydraulic integrity of the canal system.

In West and Central Java, water allocations are reviewed every fifteen days and a new set of planned discharges recalculated. To achieve this, each irrigation inspector (*juru*) is charged with the task of assessing the area currently planted to each major crop category within each tertiary block under his jurisdiction. This is then modified by an assessment of expected changes in land use within the forthcoming fifteen-day period. This enables expected changes such as the harvest of existing crops or the land preparation for the next season to be included in subsequent calculations. East Java uses another derivative of the pasten system, called "Factor Palawija Relatif" or FPR.

The data collected by each *juru* is forwarded to the subsection office where the resident subsection head (*pengamat*) enters the data for each block on a form and applies a set of standard factors to calculate total water demand at each structure in the system. These factors include the estimated crop water requirement for each major crop type, modified to allow for growth stage, and the presence of any rice in excess of the permitted total authorized, which must be reclassified. In some cases additional factors are included such as soil, drainage and topographic influences on water demand. A tertiary-level distribution efficiency is also factored in at this stage.

The data for each tertiary block served by a single secondary is cumulated and a conveyance loss factor applied. and the process repeated at main canal level. This results in a single figure for total system water requirement.

To determine the value of Factor-K, estimates also have to be made of discharge available to the system at the weir. The normal practice is to assume that the discharges recorded in the current fifteen-day period will be available in the next fifteen-day period. While this approach has obvious limitations when there is a period of steadily declining base flow with short-term peaks due to local rainstorms, there is no alternative procedure in general use.

As long as Factor-K (estimated supply divided by estimated demand) is equal to or greater than 1.0, the planned discharges are simply determined by cumulating tertiary-level demand and applying the conveyance loss coeffiient.

Appendix 2

IMPLEMENTATION OF THE MANAGEMENT INFORMATION PROJECT

The Management Information Project (MIP) activity was carried out between March and September 1989. Although it would have been possible to have condensed this time frame considerably, it was decided that it was important to make the activity an incremental one that would not disrupt routine ongoing tasks and would provide the opportunity to undertake the tasks under a range of hydrologic conditions.

The activity fell into three main parts: (1) a training program that provided orientation and a refresher course in basic measurement techniques, (2) a phase of initial data collection. (3) field implementation of the new techniques and their incorporation into normal operational procedures.

Training

The first stage of the MIP training was conducted at the West Java PRIS office in Bandung from March 20 to 23 1989. This included classroom presentation and discussion for two days, and two days in-field training in the Ciherang System in the Bandung Section. This training was attended by region (*wilayah*), section, and subsection heads for all five Advanced Operations Unit areas and the Maneungteung System; and seven temporary, full-time MIP field supervisors—one from each region office, one from each section office, and one from the province office. Provincial-level officials, a representative from DOI in Jakarta, and involved IIMI staff also attended. Over forty participants attended the training, which was presided over by the West Java PRIS, and conducted by IIMI. The locations of the sample systems and Advanced Operations Units can be seen in Figure 9.

Following me training in Bandung, two days of intensive field training was conducted in each of the four areas listed above for all sub-section heads and staff, irrigation inspectors and involved weir and gate keepers. Training was done by IIMI staff and the special MIP supervisors from the province, region, and section offices. Sixty staff members were given this training. An additional two days of field training were given to about 20 staff members at the Ciranjang Subsection in Cianjur Section, on their request. Repeated on-the-job training and supervision were given to involved field staff over the six-month duration of the activity. Altogether, approximately 150 people (mostly PRIS staff) were involved in the field-level implementation of the MIP activities. This includes village-level heads of economic and development affairs (*Ka Ur Ek Bang*) and a few farmers who assisted the mapping and calibrating teams.

Initial Data Collection

Immediately following training, field staff began collecting data to enable the planning of MIP activities. This involved on-site inspection of structures and interviewing of gate operators and farmers. It also involved the functionality of gates and measurement structures in their systems, perceived accuracy of official command area figures in the tertiary blocks, location of suppletions, and an assessment of WUA development needs. On 10 April 1989 the MIP supervisors and six subsection heads met in Bandung to discuss the preliminary data collected and develop the implementation phase.

Implementation

The MIP activities were implemented in the four pilot systems between mid-April and the end of September 1989. In the initial stages, the MIP supervisors developed a program whereby each sub. section would concentrate on a particular activity for one or two days under close supervision and guidance. As local experience and confidence increased, the intensity of supervision was relaxed. Much of the success of the effort was due to the hard work of Ir. Busra (DOI—1), Ir. Sudarmanto and Ir. Wawan (West Java PRIS) of the IIMI team.

Figure 9. Location of sample systems and Advanced Operation Units, West Java.