Design-Management Interactions of Malaysia's Kerian Irrigation Scheme

ALFREDO VALERA
and
MOHD. NOR BIN HJ. MOHD. DESA

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Please direct inquiries and comments to:

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

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Cover photographs by Mohd. Nor Bin Hj. Mohd. Desa: A main canal flume of the Kerian Irrigation Scheme; The Kerian surface pump house; A constant head orifice of the Kerian Irrigation Scheme; and a farm drain, drawing off excess water from a farm.

Contents

List of Figures

List of Tables

Abbreviations and Acronyms

cumecs	—	cubic meters per second
cu.m. or m^3	—	cubic meter
cusecs	—	cubic feet per second
ha	—	hectare
l	—	liter
m	—	meter
mm	—	millimeter
Mm^3	—	million cubic meters
M$	—	Malaysian dollar (Ringgit) [US$1.00 = M$2.66 in 1989]
s	—	second
yr	—	year
AFO	—	Area Farmers' Organization
AJKKK	—	Village Security and Development Committee
BPM	—	Bank Pertanian Malaysia
CHO	—	Constant Head Orifice
DID	—	Department of Irrigation and Drainage
DOA	—	Department of Agriculture
FOA	—	Farmers' Organization Authority
IIMI	—	International Irrigation Management Institute
MARDI	—	Malaysian Agricultural and Research Development Institute
RWS	—	Relative Water Supply

Foreword

EVERY IRRIGATION SYSTEM is different from all others. Each has its own peculiar combination of terrain, water sources, climate, soils, farmers, crops, and irrigation facilities. Within that matrix of opportunities and constraints, each system achieves some level of performance. A concern of managers, and other participants in the system, is to seek ways of raising or at least sustaining that performance level.

A central question is the interplay between "hardware" and "software," in influencing performance results. The specific physical characteristics of a canal system and its equipment seem to influence its performance outcome; but so do management decisions and operational actions. Ideally, we should like to see a good matching or complementarity between these aspects. Physical facilities should be designed in a way that is appropriate to the available management skills and resources; operating organizations should be designed, likewise, in a manner that is adequate for successful utilization of the physical facilities. If hardware and software genuinely complement each other, we should see the benefits of that matching, in high levels of performance.

In 1988, IIMI and the World Bank agreed to pursue independent but coordinated series of studies whose aim is to clarify these matters. The chosen means of investigation is through case studies of specific systems in a range of different country environments, where already existing data resources can be used to describe the physical context, the operational activities, and the performance outcomes. With the accumulation of a data bank from many such studies some generalized explanations of the ways in which these factors interact may ultimately be sought.

Case studies of this kind can only be accomplished where the operating organizations are frank and cooperative in welcoming and assisting the investigators, and in making their data available. IIMI is therefore happy that its first study of this kind, which is reported in this book, was undertaken in partnership with the Department of Irrigation and Drainage of Malaysia, whose Director General, Dato' Ir. Haji Shahrizaila bin Abdullah, encouraged and facilitated the work. The Department's staff, as well as those of other involved organizations, were at all times most helpful in giving access to information.

The outcome is a most interesting profile of the Kerian Irrigation Scheme, an old irrigation system that underwent rehabilitation in the past decade. The study is particularly enlightening about the difficult questions of irrigation intensity and the agency/farmer coordination that are essential if this indicator of performance is to be maintained at high levels so that the constructed facilities can achieve their potential.

The two collaborating authors are to be congratulated for their successful efforts in identifying and organizing this large quantity of illuminating data.

Charles L Abernethy
Senior Technical Advisor

Preface

THIS PAPER REPORTS the results of one study in a series undertaken by the International Irrigation Management Institute and the World Bank. The purpose of this series of studies is to collate comparable data on a large number of surface irrigation systems around the world, and set up a database from which general conclusions concerning the mutual interactions of system design characteristics and system management arrangements, and their effects upon system performance may be drawn.

This paper has been presented to the staff of the Department of Irrigation and Drainage (DID) of Malaysia, the Monitoring and Evaluation Unit of the Ministry of Agriculture, the State Government of Perak and the Malaysian Agricultural Research and Development Institute (MARDI) for their comments and suggestions.

The study and the preparation of this paper would not have been possible without the assistance and generous cooperation of the staff of DID (at its headquarters in Kuala Lumpur and at the Kerian Irrigation Project Office in Bagan Serai, Perak), Project Monitoring Unit of the Kerian-Sg. Manik Integrated Agricultural Development Project, Monitoring and Evaluation Division of the Ministry of Agriculture, Department of Statistics of the Prime Minister's Office, and other offices that provided much information and data for this study. We are very grateful to all of them and to Mr. Nimal A. Fernando and Mr. Kingsley Kurukulasuriya for editing this paper.

Responsibility for the conclusions and interpretations of the data in this report rests with the authors.

Alfredo Valera
Irrigation Specialist, IIMI

Mohd. Nor Bin Hj. Mohd. Desa
Engineer, Department of Irrigation and Drainage, Malaysia

Summary

BACKGROUND

THIS STUDY IS one of a series undertaken with the overall objective of improving the understanding of the design and management interactions of surface irrigation systems and the way they influence the performance of the systems. Through these series of studies, comparable data on a large number of irrigation systems in the world will be collated to create a database from which general conclusions concerning design and management interactions and their effects on system performance may be drawn. The Kerian Irrigation Scheme in Malaysia was selected for this study, primarily due to the availability of data for analysis and comparison. Objectives of the study, specifically for the Kerian Irrigation Scheme, were: 1) to determine effects of the rehabilitation design and actual management interactions on performance, and 2) to suggest ways to improve the existing level of performance. The data for the six seasons preceding the study were used in assessing the performance of the scheme.

SYSTEM

The scheme has a service area or command area of 24,000 hectares (ha), divided into 8 compartments, designated A to H. The upstream compartments E to H get their supply from the Bukit Merah Reservoir while the downstream compartments A to D, on the coast, get their supply from the reservoir supplemented by the Kerian River through the Bogak Pumping Station. The reservoir is also used as a source of domestic and industrial water. The reservoir was built in 1906 but the pump was installed 70 years later, in 1976. The scheme was rehabilitated in 1978 as part of the

Kerian-Sungei Manik Integrated Agricultural Development Project. The scheme is operated and managed by the staff of the Department of Irrigation and Drainage (DID) in the State of Perak.

SYSTEM DESIGN

The upstream control method is used in the Kerian Irrigation Scheme. Delivery of irrigation water is controlled upstream of the system. Measurement and control are provided by 620 Constant Head Orifice (CHO) structures provided at the secondary and tertiary canals. The major hydraulic assumption used in the design was that the water levels in the canals would be stable or that any fluctuation of levels in the canals would be relatively insignificant. Consequently, field staff were assumed to be trained in the regular operation of these CHOs for control and measurement.

Operations. The operational design of the system called for an irrigation demand (for rice) of 2.3 l/s/ha for 30 days of pre-saturation and half of this volume during the regular irrigation period for the growth stages. In determining this demand, it was assumed there would be an overall design irrigation efficiency of 70 percent and 30 percent effective rainfall.

The cropping pattern was designed to include three schedules, one for each irrigation block, with each block consisting of two to four compartments. A monthly interval between irrigation blocks was designed to reduce peak demand load. This cropping schedule was also designed to attain a cropping intensity of 190 percent by 1993. The main season is from August to February and the off-season from February to July. The main assumption in this plan is that farmers will adhere to the cropping schedules.

Management. There are "nominally" 353 operation and maintenance (O&M) staff. Approximately 267 are assigned to the field. There are, effectively, 52 Gatekeepers/Line Operators and the rest are Maintenance Workers. The Gatekeepers manage "nominally," on the average, 20 control structures, covering an average canal length of 17 km. To facilitate this task, the Gatekeepers and Irrigation Overseers are provided with transportation allowances. In practice, 2 gates are operated minimally (tidal control gates) and 42 maximally (CHOs closely spaced in secondary canals). There are 37 Supervisors comprising Irrigation Inspectors and Overseers.

Regular, weekly and monthly meetings are held among the DID staff. Meetings with other agencies as well are undertaken regularly. Occasionally, meetings are conducted with farmers through the Area Farmers' Organizations (AFOs) or the Village Security and Development Committee (AJKKK). The operational plan emanates from the District Engineer's Office and is presented to the district-level committee of the Kerian Integrated Agricultural Development Project for coordination. Operational procedures are based on the Operations Manual provided by the project and are regularly updated on the recommendations of the Commissioning Teams for each compartment.

Farmer participation. There is no water users' association in the scheme. The main operational participation of the farmers is in the opening and closing of farm offtakes. Farmers also provide maintenance (clearing of canals) for about 77 percent of the canals but they are paid by DID for this task through the AFOs or the AJKKK. The AFO is the organization nominally concerned with crop production activities including irrigation. These activities are usually undertaken by the AJKKK. Farmers' interactions with the DID field staff are encouraged with the presence of field officers at the Farmers' Development Centers (FDCs). There is no direct or active participation of farmers in the allocation and distribution activities of the scheme.

DESIGN-MANAGEMENT INTERACTIONS AND PERFORMANCE OF THE SCHEME

The design assumptions for measurement and control were based on the prerequisite of using CHOs. With fluctuating water levels in the secondary canals, CHOs were used only as control structures in the tertiary canals. In the absence of tertiary canal flow measurements the "eye-ball" estimates of water adequacy, made by field staff through experience, were deemed to be sufficiently accurate. However, the scheme was designed for intensive measurement down to the tertiary canals. The field staff have operated these CHOs with the available measurement and control structures and limited resources, to cope with the actual demands of the farmers. Interactions of design deficiencies and actual management have affected the performance of the scheme.

Allocation and distribution. The water allocation among compartments needs further assessment. Demand estimation, particularly in compartments B, C, D and G, has to be adjusted to reflect accurate estimates and to avoid excessive supply. Pre-saturation and percolation requirements have to be reduced. The "negative" irrigation or drainage reuse in compartments B and C has to be accounted for in the supply estimation.

The distribution was not equitable, with compartments E, F and H consistently receiving almost twice the estimated demand for the last six seasons. However, this inequity did not result in any reduction in yield in other compartments. Shortage of water supply in the downstream compartments was prevented by the Bogak Pumping Station and the mobile pumps provided by DID to farmers whose fields were difficult to irrigate because of higher elevation and inaccessibility to irrigation canals. These mobile pumps were also used for drainage.

Performance indicators. To assess the effects of design and management interactions, three performance indicators were used in this study: the relative water supply (RWS), the cropping intensity, and the water productivity index.

The use of the RWS measure as an indicator of performance enabled to point out the allocation and distribution performance of the system. Moreover, the adequacy of supply to the demand was also highlighted by the RWS. The overall RWS value of 1.43 or an irrigation efficiency of 70 percent was estimated assuming a 30-percent effective rainfall. However, this estimate is dependent on the assumed effectiveness of rainfall. Compartments B, C, D and G were estimated to have an average RWS value of about 1.5, with the drainage reuse for compartments B and C being accounted for as supply.

The cropping intensity at the Kerian Irrigation Scheme reached 181 percent in the cropping year 1987 and declined to 158 percent in 1989. This indicator also reflected the allocation and distribution performance of the system. Diminishing of the area irrigated or planted in the off-season accounted for this decline in the cropping intensity. Labor shortage and scheduling difficulties were considered the major constraints in the off-season cropping period. Farmers did not adhere to the cropping schedules, making the assumptions of the plan for attaining a 190-percent cropping intensity doubtful in the coming years.

Agricultural production. The indicator used to describe agricultural performance of the scheme was the water productivity index. This index is the ratio of the estimated gross rice production to the total volume of water delivered with or without the inclusion of rainfall. Thus, yield and water supply were estimated and measured to indicate the productivity of water. Yields dropped drastically starting in the main season of 1987/1988. This resulted in an overall productivity index of only 0.12 kg/m^3 and 0.214 kg/m^3, with or without the inclusion of rainfall. This also illustrates the potential of the effective use of rainfall. These are low values considering that the potential for optimum water productivity for rice is in the range of 0.7–1.1 kg/m^3 under experimental conditions. In farmers' fields, the realistic range of the water productivity index will be from 0.3 to 0.5 kg/m^3.

The decrease in yield also reduced the profitability of irrigated rice farming despite the subsidies in fertilizer, irrigation, credit and rice price. Although only 37 percent of the total monthly income is derived from rice farming, there are opportunities to improve profitability in farming. Unless the profitability of irrigated rice farming is increased, it is doubtful whether farmers will spend more time in farming activities.

OPPORTUNITIES FOR SYSTEM PERFORMANCE IMPROVEMENT

The suggestions for improving system performance are directly related to the design and management interactions. These are for improving the supply-increasing, demand-reducing, monitoring and evaluation activities. Most of these suggestions have to be implemented by the DID field staff while some of the activities involved have to be undertaken by the farmers. The supply-increasing activities will involve effective utilization of rainfall through a supply-demand plan, reduction of distribution losses by equitable distribution, and calibration of the Bogak Pump. The demand-reducing activities include more accurate assessment of pre-saturation requirements including seepage and percolation estimates and undertaking field leveling and building of field ridges on farmers' fields. Regular monitoring and evaluation activities not only of irrigation water supply but also of the performance of the DID field staff will redound to better relationships with farmers in terms of conforming to the cropping schedules.

CONCLUSIONS

The design and management interactions at the Kerian Irrigation Scheme were manifested in the allocation and distribution aspects of the scheme. Provisions were made for 620 CHOs for intensive measurement and control down to the tertiary canals. With fluctuating water levels in the canals and limited resources for the deployment of field staff, control and measurements were only done in the secondary canals. Use of "eye-ball" estimates of the adequacy of field water based on the experiences of the field staff became an acceptable practice. This resulted in the overestimation of demand leading to excessive supply (more than twice the estimated demand) to upstream compartments.

Despite this apparent inequitable distribution, with an assumed effective rainfall of only 30 percent, the estimated overall RWS value was 1.43; an equivalent irrigation efficiency of 70 percent was obtained in 6 cropping seasons. Though this may be considered high, opportunities to improve the effective use of rainfall and to reduce distribution losses can lead to reduced pumping costs and the saving of water in the reservoir.

The design of cropping schedules and the subsequent management have affected the cropping intensity of the scheme. Initially (i.e., in 1987), a high cropping intensity of 181 percent was attained. However, yearly cropping intensities have declined since then. Farmers have not kept to the cropping schedules as assumed in the plan. Moreover, irrigation and drainage facilities were not completed as planned, leading to delays in water supply for land preparation. With the completion of these facilities by the Commissioning Teams, timely delivery of water is expected.

The indifference of farmers to the cropping schedules was attributed, among other factors, to the generally declining interest in rice farming. Despite the subsidies provided by the government, low profitability was the major reason for this waning interest. Only about 37 percent of the total income of farmers is derived from rice farming. Unless irrigated rice farming becomes profitable enough, enabling farmers to stop doing other work and devote more time to farming activities, it is doubtful whether the existing system performance will be improved.

CHAPTER 1

Introduction

THE IRRIGATION SYSTEMS in different countries have different types of physical infrastructure, operating rules, organizational structures and management practices. They differ widely in their performance in terms of technical and economic efficiencies, productivity and equity results, and manageability and sustainability of the systems. In order to improve the performance of systems, it is necessary to assess and evaluate the current performance, analyze the determinants of the performance, and identify opportunities for improvement at various levels — policy, technical and managerial.

More recently, the financing of irrigation services and budgetary allocations for operation and maintenance (O&M), farmer participation, and staff training have also received considerable attention. The performance of irrigation systems is highly dependent on the effective management of the allocation, conveyance and distribution of water at the main canal and distributary channels down to the tertiary system. This aspect has not received adequate attention. The concepts and principles adopted in the design of the main canal and distributary channels and the regulating structures, the technologies used, and the operating practices that can be adopted determine the manageability of a system or the levels of difficulty in managing a system. A study of these design and management interactions and their influence on the performance of irrigation systems can make a significant contribution to improved irrigation management, especially in the context of rehabilitation and modernization of systems.

In Malaysia, one of the countries selected for this study, the focus of the research was on the Kerian Irrigation Scheme and the Kemubu Irrigation Scheme. The overall objective of the study is to improve our understanding of the design and management interactions of irrigation systems and the way they influence the performance of systems. The specific objectives of the study on the Kerian Irrigation Scheme were to: 1) determine the effects of the rehabilitation design and actual management interactions on the performance of the scheme; and 2) suggest ways to improve the existing level of performance.

For this rapid appraisal study, secondary information was collected from reports, visits to the scheme, and discussions held with the concerned staff of the Department of Irrigation and Drainage (DID) and the Project Management Unit of the Integrated Agricultural Development Project of the scheme. The data analyzed for this study are for the years 1987, 1988 and 1989, and the results of the study should be viewed within the limitations of the data used.

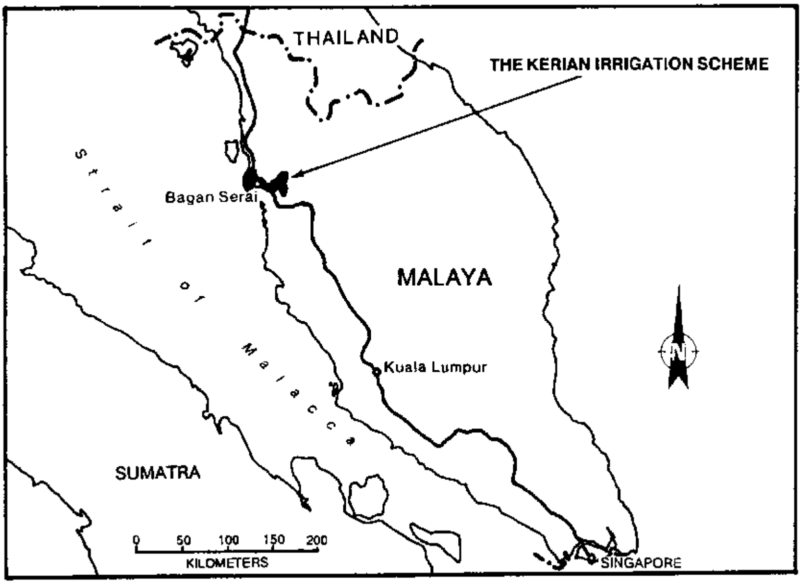
CHAPTER 2

System Characteristics and Design

SYSTEM DESCRIPTION

THE KERIAN IRRIGATION Scheme is located in the northwest corner of the State of Perak in Peninsular Malaysia. The office of the scheme is located in the town of Bagan Serai, 50 km northwest of Taiping (Figure 1) and the scheme is operated and managed by the Department of Irrigation and Drainage (DID) (Figure 2). All systems in Malaysia excepting the Muda and Kemubu Irrigation schemes are managed by DID.

Figure 1. Location of the Kerian Irrigation Scheme, Perak.



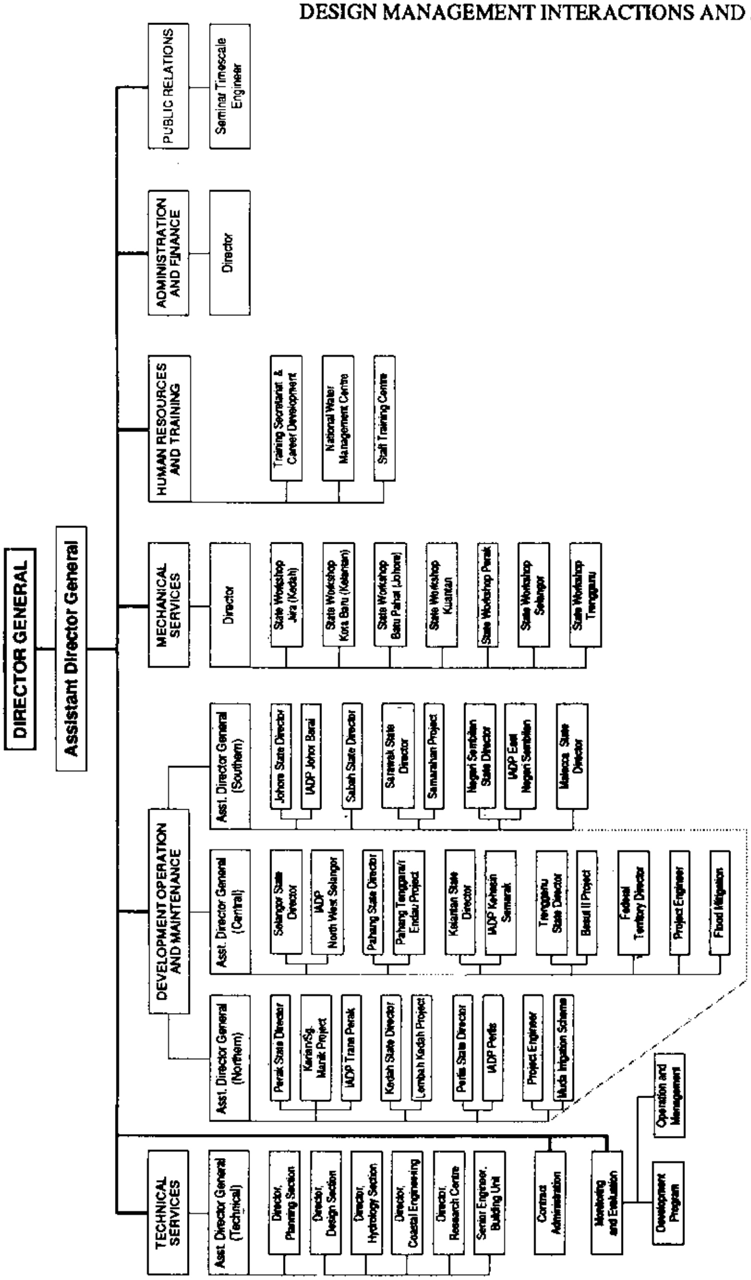


Figure 2. Organizational chart of the Department of Irrigation and Drainage, Malaysia (1988).

The scheme has a command area (irrigated area) of 24,000 ha. There are eight irrigation sections or compartments, designated A to H. Compartments A to D are located on the coastal side (referred to as Kerian Laut). Compartments E to H are located inland (referred to as Kerian Darat). The scheme is managed by the staff of the Department of Irrigation and Drainage, headed by the Project Engineer.

The main supply of water for the scheme comes from the Bukit Merah Reservoir built in 1906. The reservoir is fed by the Kurau River and two small rivers which include the Merah River. Based on 1985/1986 estimates, the reservoir can yield an annual volume of about 530 Mm^3 of water. The reservoir area is about 34 km^2 while the catchment area is about 480 km^2.

The active storage of the reservoir is 56 Mm^3 with a dead storage of 19 Mm^3. Although the reservoir was designed to store water up to a capacity of 93 Mm^3 this capacity could not be reached due to the settlement of a railway embankment. There is a plan to raise this embankment to attain the maximum potential storage of the reservoir dam. Thus, the present full supply level is at 8.69 m with a storage of 75 Mm^3. The maximum available supply from the reservoir is approximately 2,333 m^3/ha or about 233 mm. This is only sufficient to supply about 23 percent of the entire command area, for one season, assuming a requirement of 1 m/ha for the total seasonal water supply for rice.

The water supply for the scheme is supplemented by a pumping station. There are four electrical pumps, with a capacity of 5.1 m^3/s each, pumping water from the Kerian River (Figure 3). A barrage was constructed to provide the appropriate water level for the pumping station and also to prevent intrusion of salt water into the river. The pumping station was built in 1976 and it can provide supplementary water to compartments A to D. It can also supply parts of compartments E and F during periods of inadequate supply from the reservoir.

CLIMATE

The scheme has a humid tropical climate with high rainfall, and temperatures around 27-28 degrees Celsius (Table 1). The rainfall is bimodal with peaks

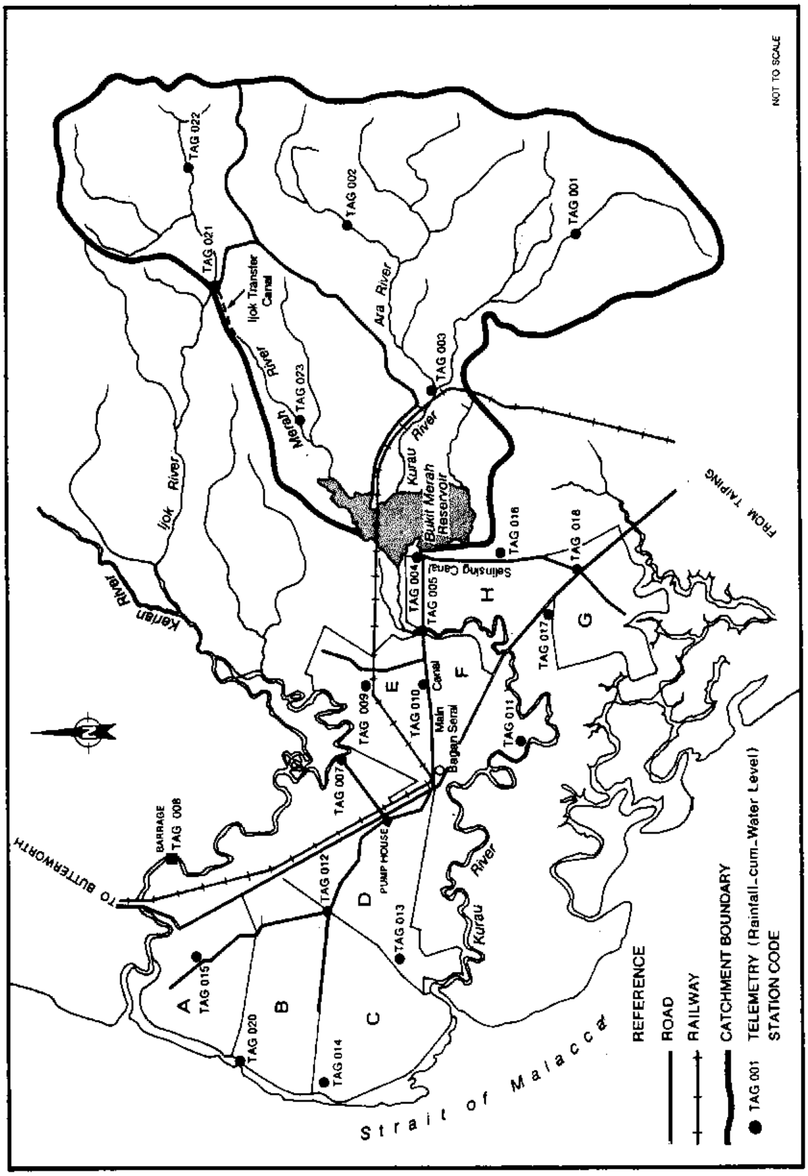


Figure 3. Kerian Irrigation Scheme and catchment area of Bukit Merah Reservoir.

in April and October with a precipitation of about 2,500 mm. Despite the high rainfall, the Coefficient of Variation exceeds 50 percent for most months. With this high variability of rainfall, supplementary irrigation from the reservoir or the pumping station is necessary, particularly during pre-saturation periods and critical growth stages of the rice crop. The northeast monsoon brings about high rainfall from September to December, requiring appropriate drainage.

TOPOGRAPHY

The terrain in the scheme is characterized by an alluvial plain in the west coast that slopes gently with a gradient of about 0.01 percent. This is reckoned from the Bukit Merah Reservoir (4 m above msl) to the plain area of Kerian Laut (0.8 m above msl) for a distance of 29 km. Compartments A to D are flatter than the others. In particular, compartments G and H are undulating in topography.

SOILS

The coastal portion of the scheme, located mostly in areas of compartments A to D, comprises mainly alluvial soils of marine origin. The marine clay is characterized by a thin brown sticky clay surface layer covering a subsoil that is a structureless greenish-gray clay. These soils are mostly flooded and little mottling has occurred. The inland area in parts of compartments E to H are mostly of alluvial soils of riverine origin. About 5,000 ha of land along the Bagan Serai-Parit Buntar Road is overlain by slightly acid organic clay muck soils. These are in portions of compartments A, B, D and F. The soils at Kerian Laut are considered very suitable for rice growing, but they have a low load-bearing capacity due to their flooded condition. The muck soils, on the other hand, are less productive but with suitable soil and water management, rice growing will become profitable.

Table 1. Climatic factors at the Kerian Irrigation Scheme.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Average
Average rainfall (mm)[a]	151	141	207	244	197	121	146	168	216	366	295	217	2,469	
Average open panevaporation (mm)[b]	148	146	161	152	152	154	157	161	151	151	139	139	1,811	150
Average daily temperature[c] (degrees Celsius)	27.0	27.2	27.7	27.8	28.0	27.8	27.6	27.4	27.2	27.1	26.9	26.9		27.3

[a]Average of six stations within and along boundaries of subproject area for 27 years (1948–1974).
[b]Average of three stations.
[c]Average of two stations.
Source: Appraisal Report of the Kerian-Sungei Manik Project, 1978 September.

FARM SIZE AND TENURIAL STATUS

There are approximately 20,000 farmers in the scheme. The average farm holding in 1988 was 1.471 ha. There have been gradual changes in the landownership patterns before and after the rehabilitation of the scheme starting in 1978. As of 1987, there were 43.5 percent of owner-operators, 28.7 percent of tenants, and 25.7 percent of owner-tenants (Table 2).

Table 2. Landownership at the Kerian Irrigation Scheme, 1975 and 1987.

Type of landholding	Percentage	
	1975	1987
1. Lanowner	66	43.5
2. Tenant	19	28.7
3. Owner-tenants	15	25.7
4. Others	–	2.1

Note: Owner-tenants are farmers who not only own land but get leases of other land concurrently. The others are pure tenants, landowning farmers, tenants of government lands or those who have rights to farm government-owned land.

Sources: 1975 data: Appraisal Report of the Kerian-Sungei Manik Integrated Agricultural Development Project, September 1978. 1987 data: Kerian Irrigation Project. 1988. Early findings of the poverty study.

SYSTEM DESIGN CHARACTERISTICS

Starting in 1978, the Kerian Irrigation Scheme was rehabilitated under a World Bank loan (Loan 1632-MA). This project included the Sg. Manik Scheme and the Dam Safety Study for the Muda Scheme, but only the Kerian Irrigation Scheme will be discussed in this report. The major objectives of the project were to increase rice production and improve farm incomes. The rehabilitation project was planned to be completed in five years. However, there was a five-year delay which doubled the appraised cost of the project (for details see Project Completion Report Malaysia [Loan 1632-MA], September 1987). The following are the major design features of the completed project.

Irrigation and road network. Two main canals, "Main Canal" and Selinsing Canal, convey water to compartments A to F, and compartments G and H, respectively. The total lengths of the main, secondary, and tertiary canals are 56 km, 327 km and 368 km, respectively. These result in an average canal density of 31.2 m/ha. The main and secondary canals are earth canals while the tertiary canals are concrete-lined. The original design was to provide glass-reinforced polyvinyl (GRP) canals as tertiary canals. With the escalation of costs, concrete-lining was provided instead. This contributed to the delay in completion of the project which in turn contributed to its cost overruns. Offtake structures are of the Constant Head Orifice type of control and measurement structures numbering about 620. Farm offtakes numbering more than 8,000 are provided with either butterfly-type or guillotine-type valves. Two farm lots are designed to share one farm offtake. The scheme operationally functions as an upstream control system. Water control in the main canal is made through cross-regulators with screw-down gates used as undershot structures with side weirs. CHOs are provided as offtakes and end control structures both in the main and secondary canals and these function as control structures. There are approximately 706 irrigation structures with gates in the scheme (Table 3).

In addition to the main canal road, secondary canals were provided with the farm roads on the canal bund, with the wider side (3.6 m) surfaced with laterite. The average density of roads is 16 m/ha allowing the passage of vehicles weighing only 3 tons or less. Crossings for heavier vehicles (5 tons) are also provided so that most farms are within 0.8 km from the roads which can carry heavier loads.

Drainage network. The scheme also has a network of secondary and tertiary drains, with lengths of 580 km and 180 km, respectively. The ultimate drainage is provided by the Kurau and Kerian rivers and 11 major drainage outlets flowing directly into the Strait of Malacca. Bunds or protection dikes were constructed to reduce flooding and to provide protection from the influx of sea water in the coastal areas of the scheme. The total length of river and coastal bunds is 110 km. There are 204 gated drainage structures in the scheme (Table 3).

Table 3. Number of irrigation and drainage control structures at the main and secondary canals by compartment.

Structure	Compartment								Total
	A	B	C	D	E	F	G	H	
IRRIGATION X-Regulator	–	1	1	1	–	1	1	1	6
CHO	88	56	88	87	38	56	63	88	564
IEC	15	11	6	28	22	15	19	20	136
Subtotal	103	68	95	116	60	72	83	109	706
DRAINAGE DC	–	–	4	–	1	2	–	–	7
DEC	32	11	8	18	12	6	11	6	102
UDC	7	7	7	2	3	2	5	5	38
TCG	9	2	5	5	7	16	9	4	57
Subtotal	48	20	24	25	23	26	25	15	204
Total	151	88	119	141	83	98	108	124	910

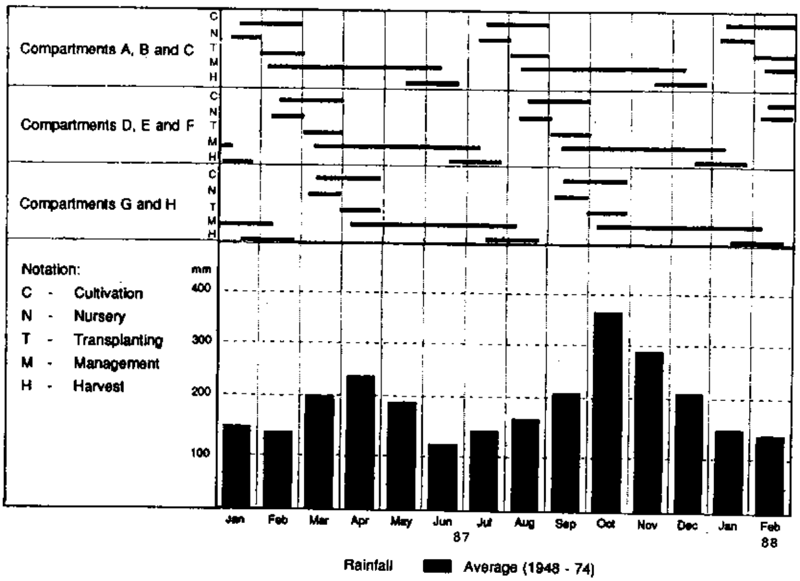
Notes: X-Regulator = Cross Regulator (across the main canal)
CHO = Constant Head Orifice (double-gated turnout)
IEC = Irrigation End Control
DC = Drainage Control
DEC = Drainage End Control
UDC = Under Drainage Culvert
TCG = Tidal Control Gate
Average density of control structures is 18 structures per staff (actual range is 2 to 42 control gates).

The alignment of tertiary irrigation and drainage canals usually follows the lot boundaries, but in some instances this alignment is not possible, particularly in portions of compartments A, B, C and G. The drainage density is approximately 31.7 m/ha and the ratio of drainage to irrigation is about 1.02. At the Kerian Irrigation Scheme, the drainage density is greater than the irrigation density due to the flat terrain and exposure of some parts of the scheme to tidal inundation. This is observable in compartments B and C and in some portions of A and G. More tertiary drainage canals were built in these compartments and these were also used as irrigation canals during drainage reuse or "negative irrigation."

Operational design requirements. The irrigation water demand for rice cropping was designed for a pre-saturation duration of 30 days with 2.3 l/s/ha (one cusec per 30 acres or 19.9 mm/day). This is estimated on a soil saturation of 150 mm, a standing water value of 100 mm, a percolation rate of 1.8 mm/day and an assumed overall irrigation efficiency of 70 percent. Irrigation water demand during the growth stage is half that of the pre-saturation stage, i.e., 1.16 l/s/ha or one cusec per 60 acres.

The cropping pattern and schedule of irrigation water deliveries to the different compartments were designed according to three proposed irrigation blocks with a monthly interval between blocks. This cropping pattern will enable the scheme to effectively use the rainfall in both seasons, harvest during drier months, reduce peak load during the pre-saturation period and attain a cropping intensity of 190 percent by 1993 (Figure 4). The off-season is usually from February to July and the main season from August to January.

Figure 4. Kerian Integrated Agricultural Development Project: Planned cropping schedules.



The scheme is also providing industrial and domestic water supplies amounting to 135 Mm^3 or approximately 18 percent of the total water supplied from the reservoir, the pumping station and from rainfall.[1] Thus, in estimating the total demand, the industrial and domestic demands are also taken into account.

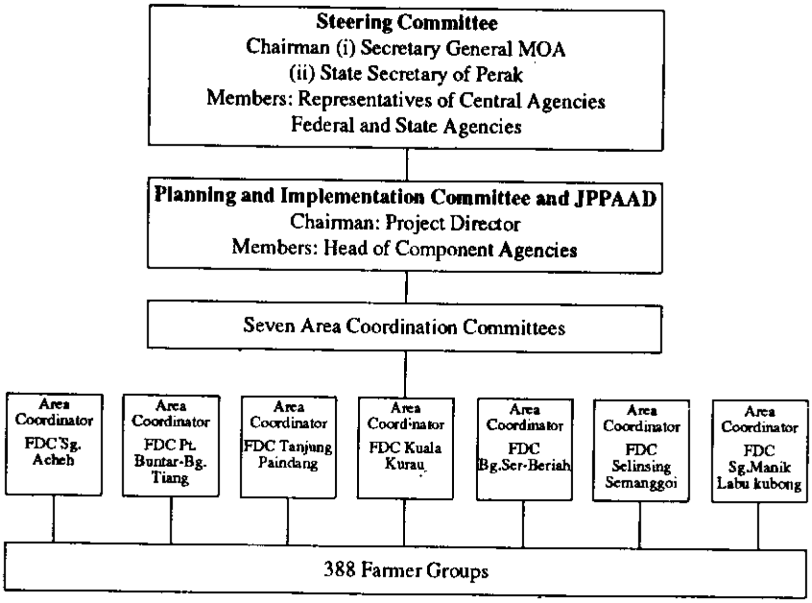
Prior to the start of seasonal operations, a meeting of the District Interagency Planning and Coordinating Committee is held at Kerian (Figure 5). The DID is a member of this committee and provides advice on the adequacy of irrigation water supply for the forthcoming season. A water budgeting or planning exercise is carried out prior to the meeting. Probabilities of the supply and demand are considered and farmers or farmer leaders are consulted, particularly if the expected supply is less than the demand by 20 percent or more. The Engineer, the Chief Irrigation Inspector and the Senior Irrigation Inspector are involved in this process.

Maintenance procedures. The maintenance program largely involves clearing of waterways and major structures. Reactive maintenance is undertaken for desilting and road/bund repairs. This strategy is adopted due to the financial allocation procedure of the Federal Government which is based on the reimbursement of expenditure made by the State. The State and the Federal Government share the O&M expenditure fifty-fifty in the case of the Kerian Irrigation Scheme and also for most of the other schemes. The clearing program is revised every year, depending on the availability of the DID field workers and funds. Only about 23 percent of the area is maintained by the DID field staff and the rest is cleared by farmers (under maintenance service contracts) and/or by contractual laborers. Most irrigation and drainage canals are cleared five times a year. All clearing is done manually except in a very few instances (2 percent) where mechanical clearing is carried out.

Major installations such as the barrage, pump house and spillway at the reservoir are visited monthly by an Electrical Engineer with the DID "Chargeman" and an Engineering Assistant. The State Mechanical Engineer also assists in the maintenance of these installations. The DID Fitter regularly

1 These estimates were based on data for the years 1985 and 1986. Rainfall contribution was assumed to be only 30 percent effective.

Figure 5. Organizational chart of the Kerian-Sg. Manik Integrated Agricultural Development Project.



Notes: FDC = Farmers' Development Center
JPPAAD = District Interagency Planning and Coordinating Committee
Members of the Steering Committee: Economic Planning Unit, Treasury Implementation Coordination Unit, Public Service Department, DID, DOA, FOA, MARDI, National Padi Board, Department of Land and Mines, BPM, Chairman State Agricultural Committee, State Financial Secretary, SEPU and others.
Members of the Planning and Implementation Committee and JPPAAD: Head of Components of DID, DOA, FOA, BPM, MARDI, Land office and others.
Members of the Area Coordination Committee: Field officers of DID, DOA, BPM, MARDI General Manager of AFO, *Penghulu* (Village Headman) and others.

visits the 11 tidal control gates of the scheme. Minor repairs are his responsibility but major tasks are contracted to outside Fitters.

Upkeep of farm roads, (canal, coastal, river, and drain) bunds and irrigation and drainage canal sections is another major maintenance task. Resurfacing of farm roads is done every four years, while topping up of bunds and desilting of irrigation and drainage canals are done every three years.

Farmers are expected to carry out maintenance of tertiary and quaternary canals through *gotong-royong*, the traditional method of group voluntary work organized by farmers or by DID. However, maintenance of these drainage canals appears to be unsatisfactory. Efforts are exerted, through extension, to convince farmers of the necessity to clear these tertiary drains.

Regular or routine maintenance such as weed clearing of canals is done five times per year, while major maintenance work such as desilting and repair of bunds is done during fallow periods or in-between seasons.

CHAPTER 3

Management

ORGANIZATIONAL STRUCTURE

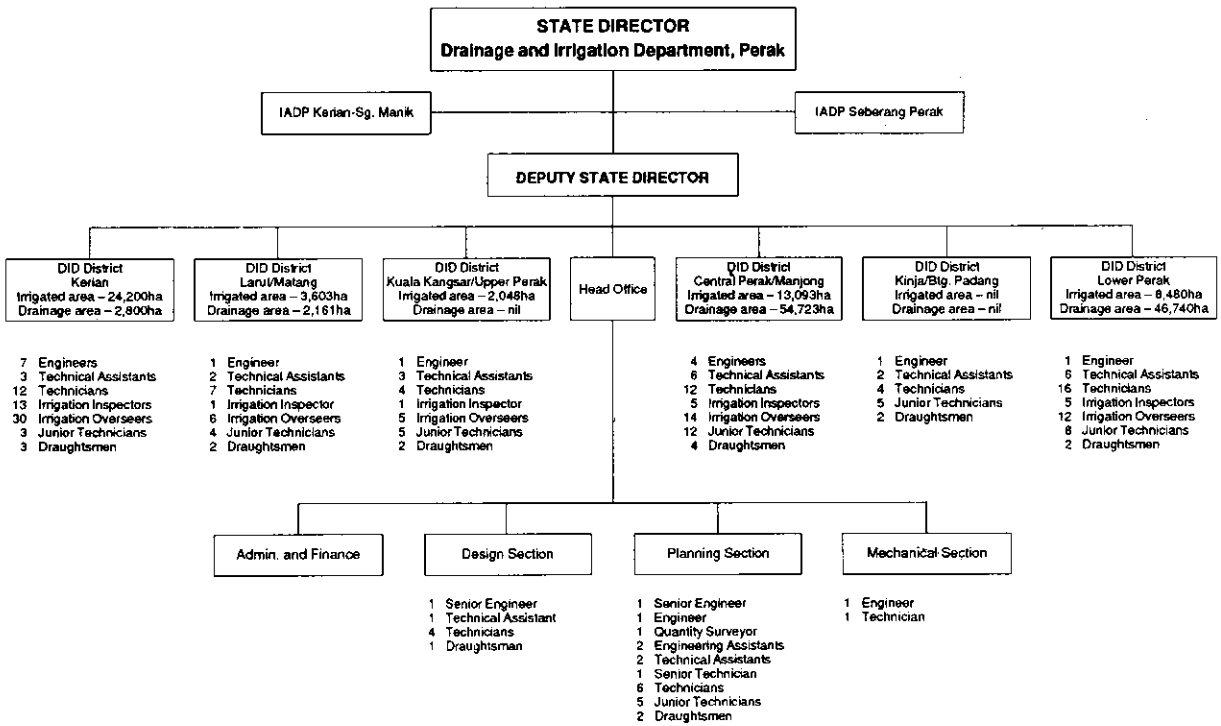
ADMINISTRATIVELY, THE MANAGEMENT of the scheme comes under the Department of Irrigation and Drainage, Kerian District of the State of Perak (Figure 6). In this district there are 353 nominal O&M staff. About 247 are assigned to the field (Table 4). The rest (106) of the staff are assigned to the Kerian Office at Bagan Serai and to the maintenance and supply shop. The actual number of staff is less than the nominal number due to retirements of some staff. However, there are only 52 Line Operators or Gatekeepers who manage, on the average, 18 control structures and about 14 km of canals. In practice, the maximum number of control structures managed is 42 (CHOs closely spaced in a secondary canal) and the minimum about 2 (tidal drain gates which are large in size). The net irrigated area per field staff (Irrigation Inspectors, Overseers and Gatekeepers) is 282 ha/staff.

"Transport allowances" are provided to Irrigation Inspectors, Overseers and Gatekeepers (Table 4) to facilitate their work in operating the gates and observing the adequacy of irrigation water within the major canal network (primary and secondary) of the scheme.

Functionally, the field staff are organized by compartment. However, staff are physically organized in accordance with the location of the Farmers' Development Centers (FDCs). There are six FDCs in the scheme, one for each subdistrict level or *Mukim* (cluster of villages). This arrangement provides an opportunity for better interaction among staff of different government agencies and also for better access to government assistance by farmers in one location.

Most of the Irrigation Inspectors and Irrigation Overseers have undergone training courses at the DID training center at Ampang, Kuala Lumpur. Some of them have attended the water management training course held at the Water Management Training Center at Kota Bharu. They have also attended

Figure 6. Organizational chart of the Department of Irrigation and Drainage, State of Perak.



seminars and workshops in agricultural production practices. Furthermore, they have been given on-the-job training (as for Line Operators) by the Commissioning Teams.

Table 4. Field staff and transport provision at the Kerian Irrigation Scheme by compartment.

Staff	Compartment								Total	Transport		
	A	B	C	D	E	F	G	H		Cars	MB	B
IIs	1		1	1	1		1		5	5		
IOs	3	5	4	4	3	3	3	3	28	5	24	
IMGs	26	37	36	30	19	19	23	24	214		44	8
Total	30	42	41	35	23	22	27	27	247			

Notes: IIs — Irrigation Inspectors MB — Motorbikes
IOs — Irrigation Overseers B — Bicycles
IMGs — Irrigation Manual Groups
One II each for compartments A&B, E&F and G&H.
Half of the IMGs for compartment A is paid by the State of Penang.
Three of the IMGs at compartment C are pump operators.
Three of the IMGs at compartment D are pump house attendants.
Additional IMGs:
6 for weed control at the main canal.
2 for reservoir gate operation.
12 for reservoir maintenance.

OPERATIONAL PROCEDURES

After the cropping schedules for each compartment have been agreed upon in the District Coordination Committee, they are distributed to the different Farmers' Development Centers or Area Coordination Committees. The schedules are also posted at *Kampong* (village) field offices or meeting sheds.

Regular monthly meetings are conducted among the DID staff comprising the Engineers down to the Irrigation Inspectors, Technicians, the Store Keeper and the Chief Clerk. The Chief Irrigation Inspector and the Senior Irrigation Inspector also meet with the Irrigation Inspectors and Irrigation Overseers, once a week. Correspondingly, in each area or Farmers'

Development Center the Irrigation Inspector meets Irrigation Overseers and the Line Operators and Irrigation Manual Groups, also once a week. Occasional meetings are also held when there are special events that need discussions between the field staff and the office staff.

An Operations Manual was made available for use by the field staff. The manual provides the operational rules for the main, secondary and tertiary canal systems and also the guidelines for the drainage operation. Changes have been made in this manual; demand estimates were adjusted in accordance with the recommendations of the Commissioning Teams and discharge coefficients of weirs and submerged orifices for the cross-regulators and CHOs were modified based on empirical measurements.

A "manage-as-planned" program or supply-demand plan was adopted as an operational procedure in 1989. This relates the supply conditions to the demand conditions of the scheme, and helps to achieve the right supply-demand position. This plan is based on the budgeting of the weekly projected water supply and demand for each compartment (Teh 1989). Weekly assessments of the water supply from the reservoir, rainfall, and pumping station are done to accurately estimate the necessary weekly adjustments of the control structures which are made by the field staff.

Two major indicators of water supply status in this plan are the water resource confidence level and the extent of pumping supplement measured in pump week (i.e., the number of pumping hours in a week) needed to keep the reservoir above the critical level. The supply-demand position is easily communicated to the field staff with the use of such facilities as VHF and telephone communications. For the farmers and concerned staff of other agencies, a color scheme depicts the supply-demand positions (Table 5). A notice is posted outside every Farmers' Development Center, depicting the supply-demand position.

A daily water allocation model for the main and secondary canal systems can accommodate changes in the daily water supply-demand position. The target efficiencies, namely: E_a (application), E_b (distribution), E_c (conveyance) and also E_f (effectiveness of rainfall), are variables dependent on the supply-demand position (Table 5).

Appropriate procedures or responses to changes in the supply-demand position are also planned in case there are shortfalls in the water resource

Table 5. Management variables (efficiencies of water use operation and monitoring requirements) in relation to supply-demand positions.

Improving efficiency of water use						Operation and monitoring requirements			
Supply demand position	Command area	Irrigation efficiencies			Effectiveness of rainfall (Ef)	Offtake adjustment	Check on DEC and IEC (see notes)	Check on farm offtake and drainage pipe and perimeter bund	Water front mapping
		Ea	Eb	Ec					
Blue	A	.80	.85	.85	30%	Twice daily	Daily	Twice weekly	Weekly
	B	.80	.85	.87					
	C	.80	.85	.87					
	D	.70	.85	.91					
	E	.65	.85	.95					
	F	.65	.85	.95					
	G	.60	.85	.93					
	H	.55	.85	.96					
Amber	All	Raise by 0.05	Raise by 0.03	No change	40%	Twice daily	Twice daily	Daily	Twice daily
	Step up irrigation extension to involve farmers' participation in reducing field losses								
Red	All	Raise by another 0.05	Raise by another 0.05	No change	50%	Once daily	Twice daily	Once daily	Weekly daily
	1. Practice rotational supply at tertiary level. 2. Step up the irrigation extension including campaigning through various established agriculture and administrative machineries. 3. Arrange finances to cater for operation outside office hours, the expected increase in pumping supplement and contracting out certain aspects of maintenance works.								

Notes: DEC - Drainage end control.
Ea - Application.
Eb - Distribution.
Ec - Conveyance.
IEC - Irrigation end control.

Source: Teh, S.K. 1989.

conditions. Monitoring, evaluating and making day-to-day decisions regarding the control of water in every compartment are necessary tasks to make this procedure effective. Moreover, a plan to accurately monitor the water supply condition is underway with the installation of telemetering devices. Water levels in the canals, the reservoir and rivers as well as rainfall stations in the command area will be monitored automatically with this telemetering capability. For a detailed discussion of this approach, refer to Teh, S.K. (1989).

FARMER PARTICIPATION

There are no water users' groups in the scheme. The farmers are passively participating in the management of the scheme in terms of water allocation and distribution. However, most farmers (85 percent) are members of the Area Farmers' Organization (AFO) as organized by the Farmers' Organization Authority (FOA). Irrigation is part of the activities of the AFO. There are formal and informal ways in which farmers communicate their water problems to DID. The formal mechanisms include regular meetings held at different administrative levels from Kampong and Mukim to the District (District Development and Action Committee) and also through the AFOs. In some instances complaints are entertained at Village Security and Development Committee (AJKKK) meetings. Requests, appeals and queries are also received by the scheme office at Bagan Serai from time to time. Most problems are, however, solved through informal mechanisms at the Farmers' Development Center level. Farmers visit the FDCs and discuss their problems with the Irrigation Inspectors, the Irrigation Overseers and the Line Operators. Sometimes, farmers take their problems to the Chief Irrigation Inspector, Senior Irrigation Overseers and even to the Engineers through personal visits or through telephone calls.

The responsibility for opening and closing of farm offtakes rests with the farmers. Irrigation is just one of the agricultural production activities of the AFOs. The more active participation of the farmers is in the maintenance activities. Through the AFO and the AJKKK, DID contracts and pays the farmers for weed clearing of irrigation and drainage canals. For the previous years, 88 percent of secondary canals, 99 percent of the secondary drains and 64 percent of the tertiary canals had been cleared by the farmers under contract with DID (Table 6).

In most cases, the quality of farmers' work in maintaining irrigation and drainage canals was better than that of laborers. This contractual procedure for maintenance provides the farmers with the simultaneous opportunity to earn extra income and to participate in maintaining the scheme.

Table 6. Proportion of irrigation canals and drainage canals cleared by farmers on contract at the Kerian Irrigation Scheme, 1987–1989.

Type of canals	1987		1988		1989		1990	
	km	%	km	%	km	%	km	%
Irrigation canals Main canals (56 km)	7	12	–	–	–	–	–	–
Secondary canals (327 km)	314	96	287	88	267	82	289	88
Tertiary canals (368 km)	204	55	241	65	259	70	235	64
Drainage canals Secondary drains (580 km)	624*	100	556	96	579	99	572	99

Notes: The total distance cleared by the farmers through the Village Security and Development Committee (AJKKK) should be actually multiplied by the number of cycles of clearing undertaken averaging four to five cycles per year.
Figures in parentheses represent the total lengths of the canals.
* The actual length of the secondary drains cleared might have included tertiary drains.

Next >>

CHAPTER 4

Actual Management and Performance

THE SCHEME WAS designed to operate with CHOs being used down to the level of tertiary canals to provide control and measurement of flow in the secondary and tertiary canals but difficulties were encountered by the field staff in operating or adjusting the CHO gates and only the CHOs of secondary canals were operated with appropriate adjustments. In some cases, outlet gates and gauges inside the CHO chamber were missing. However, with the commissioning activities, these facilities will be provided in the different compartments.

One major reason for the difficulty in operating the CHOs is the fluctuating water levels in the canals. The CHOs were designed for a relatively constant differential head between the canal water level at the inlet and the water level inside the chamber. The estimated weekly coefficients of variation of the water supply for the compartments and main canal indicate that the corresponding canal water levels were not as constant as expected to make the CHOs effective (Table 7). With fluctuating water levels in the canals, frequent adjustments will be necessary to make the CHOs more functional.

To further stabilize and provide control of the water level in the secondary and tertiary canals, 276 checks or cross-regulators and end control structures were installed in the entire scheme. However, the uncoordinated adjustment of these checks led to fluctuations in water levels and consequently to fluctuations of the supply to the different compartments. The field staff were able to cope with the fluctuations in the main canal but could not make proper use of the CHOs in most of the secondary and tertiary canals.

With these fluctuations in the canal water levels, field staff faced difficulties in adjusting the downstream gates of CHOs. These difficulties were exacerbated by the turbulent water conditions due to the small CHO chamber of small-diameter pipe, poor light conditions in the chamber and malfunctioning of the manometer in some cases. These resulted in the use of the CHOs as measuring and control structures at the head gates of all secondary canals but not at most of the head gates of tertiary canals. Some tertiary-canal CHOs were monitored for water flow measurement purposes during the commissioning period but this practice was discontinued later. The large number of CHOs for tertiary canals, in addition to making it difficult to adjust downstream gates and creating the conditions mentioned above, discouraged the field staff from effectively using the CHOs as measuring structures.

Table 7. Coefficient of variation (%) of irrigation water supply in compartments, Main Canal, Selinsing Canal, Bogak Pump and the System (total supply), 1987–1989.

Season	Compartment								Main Canal	Selin-sing Canal	Bogak Pump	Sys-tem
	A	B	C	D	E	F	G	H				
Off-season 1987	19	36	58	–	–	–	12	42	46	130	61	67
Main season 1987/1988	63	32	33	55	73	102	7	12	26	38	54	29
Off-season 1988	24	45	43	29	43	34	17	20	52	42	79	38
Main season 1988/1989	–	–	40	21	37	46	21	30	62	53	63	37
Off-season 1989	35	34	–	57	32	26	–	–	51	50	73	18
Main season 1989/1990	53	28	27	42	53	37	28	10	67	52	78	27
Average	32	38	35	40	47	48	16	22	51	61	68	36

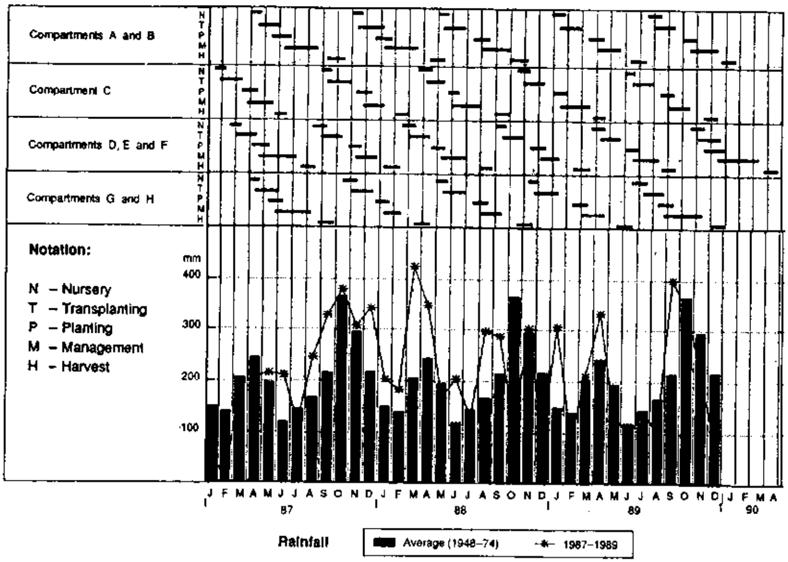
Notes: Data for compartments D, E and F for off-season 1987 are not available.
No water was supplied to compartments A and B during main season 1988/1989 and to compartments C,G and H during off-season 1989.

Thus, Line Operators/Gatekeepers used their experience to make estimates of the tertiary canal discharges and field staff used "eye-ball" estimates of the field-level water adequacy. This practice is accepted as long as the guidelines set forth in the Operations Manual are followed and farmers' complaints are kept to a minimum. With no urgency or practical reason to measure the water diverted to tertiary canals daily, recordkeeping of measurements or monitoring was also not deemed necessary by the field staff. Thus, the CHOs at the tertiary canals are not being effectively utilized as designed.

WATER ALLOCATION

The allocation of water supply is planned and carried out by compartments. Each compartment has its schedule and estimated demand. One operational objective of the scheme is to bring the compartments, in three groups, under three schedules with the aim of attaining a cropping intensity of 190 percent by 1993. The three schedules targeted for the compartments have been achieved but not in the desired sequence (Figures 3 and 7).

Figure 7. Actual cropping schedules, 1987–1990.



The estimated demands of the compartments were based on the soil-water characteristics of the entire service or command area. Compartments A, B, C and D (Kerian Laut) have less demand than compartments E, F, G and H (Kerian Darat). The major reason is that most soils in Kerian Laut are heavier in texture and flatter while in Kerian Darat, soils are lighter and the topography is less flat or undulating. However, the estimated demands for the last three years do not reflect this (Table 8), particularly in the cases of compartments B and C in Kerian Laut and G and H in Kerian Darat.

The estimated relative water supply (RWS) values were based on the mean weekly amounts of estimated demand and actual supply delivered into each compartment. The RWS is the ratio of the actual water supply (measured irrigation and rainfall) to the estimated water demand, in this case for each compartment. The mean weekly values reflect more accurately the supply-demand relationships rather than the aggregated totals at the end of the season (Table 8). The RWS values indicated in Table 8 are taken from the mean values provided in Table 10. This will be discussed further in this chapter.

The commissioning report will provide a more accurate estimate of the demand for each compartment. It is envisaged that with this new estimate, evaluation of the supply-demand position will be improved.

DISTRIBUTION AND EQUITY

The distribution of irrigation water at the Kerian Irrigation Scheme is facilitated by the operation of the Bogak Pumping Station. Approximately 20 percent of the total water supplied to the scheme is provided by the pumping station.

Despite this pumping facility, there are occasional delays in water deliveries, sometimes delays of a few days to one whole week. To prevent the inequitable distribution of water in the scheme, mobile pumps are provided to individual farmers (Table 9). These are small-capacity portable pumps (3-5 cusecs) provided by DID at no cost to the farmers.

Table 8. Total irrigation water supply (Qs), rainfall (Rn), estimated demand (Qd) and mean weekly relative water supply (RWS), the Kerian Irrigation Scheme, by compartment and by season, 1987 – 1989.

Com-partment		Season						
		OS 1987	MS 87–88	OS 1988	MS 88–89	OS 1989	MS 89–90	Average
A	Qs	0.892	1.095	0.726	–	0.981	0.981	0.935
	Rn	0.799	0.771	0.620	–	0.932	1.012	0.827
	Qd	0.975	1.013	1.013	–	0.974	0.997	0.994
	RWS	1.83	2.00	1.45	–	2.17	2.27	1.944
B	Qs	1.451	0.958	0.870	–	1.124	1.026	1.086
	Rn	0.798	1.130	0.691	–	0.968	1.046	0.927
	Qd	2.052	1.945	2.006	–	2.009	2.045	2.011
	RWS	1.17	1.07	0.84	–	1.15	1.13	1.072
C	Qs	1.082	1.170	0.830	1.021	–	0.866	0.994
	Rn	0.506	1.425	1.002	0.697	–	1.190	0.964
	Qd	2.147	1.953	2.009	2.086	–	1.999	2.039
	RWS	0.85	1.48	0.95	0.86	–	1.15	1.058
D	Qs	–	3.130	4.966	2.207	1.714	2.007	2.805
	Rn	–	1.242	1.096	0.971	0.818	0.593	0.944
	Qd	–	2.406	2.433	2.393	2.431	2.450	2.423
	RWS	–	2.03	2.77	1.48	1.15	1.13	1.712
E	Qs	–	1.569	1.390	1.590	1.774	1.552	1.575
	Rn	–	1.026	1.130	0.908	0.740	0.710	0.903
	Qd	–	0.865	1.204	1.204	1.204	1.146	1.125
	RWS	–	3.15	2.30	2.31	2.26	2.11	2.426
F	Qs	–	0.499	1.838	1.637	2.126	1.878	1.596
	Rn	–	1.028	1.092	0.933	0.806	0.670	0.906
	Qd	–	0.981	1.023	1.107	1.118	1.076	1.061
	RWS	–	1.54	3.11	2.53	2.86	2.59	2.526
G	Qs	2.272	2.695	2.761	2.088	–	1.849	2.333
	Rn	0.984	1.446	1.442	0.974	–	1.150	1.199
	Qd	2.238	2.238	2.443	2.511	–	2.330	2.352
	RWS	1.56	1.99	1.84	1.40	–	1.43	1.644
H	Qs	3.015	2.146	2.109	2.052	–	2.071	2.279
	Rn	0.946	1.201	0.951	1.030	–	1.008	1.027
	Qd	1.274	1.274	1.378	1.429	–	1.326	1.336
	RWS	3.47	2.88	2.43	2.52	–	2.59	2.778
Total	Qs	1.742	1.658	1.936	1.766	1.544	1.529	1.696
	Rn	0.807	1.159	1.003	0.919	0.853	0.922	0.944
	Qd	1.737	1.584	1.689	1.788	1.547	1.671	1.669
	RWS	1.78	2.02	1.96	1.84	1.92	1.81	1.880

Notes: Qs, Rn, and Qd are in meters.

Rainfall accounted for 54 percent, on the average, of the total amount of water supplied.

OS = Off-season, usually from February to July.

MS = Main season, from August to January.

The Qs values in compartments B and C do not include drainage reuse.

The reasons given by farmers for requesting these mobile pumps are their inaccessibility to farm offtakes or "frontages" and higher elevations of farm plots in some cases. These pumps are also used for draining farm plots, particularly in the flatter areas, especially in compartment B.

Table 9. Number of mobile surface pumps used to supplement irrigation from canal and for drainage, by compartment and by season, 1987-1989.

Season	Compartment								Total
	A	B	C	D	E	F	G	H	
Off-season 1987	–	1*	4	–	1	–	1	2	9
Main season 1987/1988	–	–	2	–	–	–	–	1	3
Off-season 1988	–	1*	1	–	–	–	–	1	3
Main season 1988/1989	–	–	1	–	–	–	2	1	4
Off-season 1989	–	1*	–	–	–	–	1	–	2
Main season 1989/1990	–	–	–	–	–	–	2	2	4
Total	0	3*	8	0	1	0	6	7	25

Note: The pumps used had capacities of 3 and 5 cusecs.
* Pumps used for drainage purposes.

The Commissioning Teams have observed that the distribution of water supply is efficient. Pre-saturation can be attained in as short a period as three weeks in every compartment. However, one of the major obstacles in attaining a faster completion of pre-saturation is the nonadherence of farmers to the cropping schedules and the absence of *batas* (field ridges).

Considering the measured irrigation water supplied to the compartments, it appears that the upstream compartments E, F and G receive more water than the downstream compartments A, B and C, despite the supply from the Bogak Pumping Station (Table 8). Compartments D and G were adequately supplied. However, an adequate water supply was provided to all compartments when needed.

PERFORMANCE INDICATORS

Performance refers to the degree of attaining the objective(s) set forth. In the case at the Kerian Irrigation Scheme, the project objectives are: 1) to increase average yield of farm holdings from 2.4 t/ha to 3.5 t/ha; 2) to increase the cropping intensity from 157 percent to 190 percent; and 3) to increase farm production of crops other than rice. At present, the only relevant objectives of the operation of the scheme are the first two.

Translating the project objectives into operational terms is not very clear or straightforward. However, the Operations Manual provides the guidelines for translating these project objectives into system objectives.

To increase yield, irrigation water has to be provided at the right time at the right amount and at the right place. Thus, timeliness, reliability and adequacy are the objectives of launching the scheme. Effectiveness in allocation and distribution, or equity has to be met to increase the cropping intensity. These then are the targets or the operational objectives against which irrigation system performance will be measured.

The actual relative water supply (RWS) measure or indicator was used to determine the adequacy and equity of irrigation water supply in this study. This indicator is the ratio of the actual total water supply (irrigation and rainfall) to the estimated demand. The supply includes the total irrigation water diverted and total rainfall, and demand is the estimated demand consisting of seepage and percolation, evapotranspiration and pre-saturation requirements. In this study, the estimated demand was based on the adjusted design water requirements for pre-saturation during the land preparation stage and on the evapotranspiration and percolation requirements of rice during the crop growth stage. Seepage was not considered a component of the water requirement during the crop growth stage and the RWS concept as used in this study was modified accordingly. This was done to utilize the diagnostic feature of the RWS concept in assessing irrigation system performance.

The RWS is approximately the inverse of irrigation efficiency. The RWS is the ratio of input (supply) to output (demand), while irrigation efficiency is the ratio of output to input. Irrigation efficiency was not used as the RWS is a more practical and realistic indicator, particularly when the actual supply falls below the estimated demand, when the efficiency value is more than 100 percent while the crop demand is not satisfied.

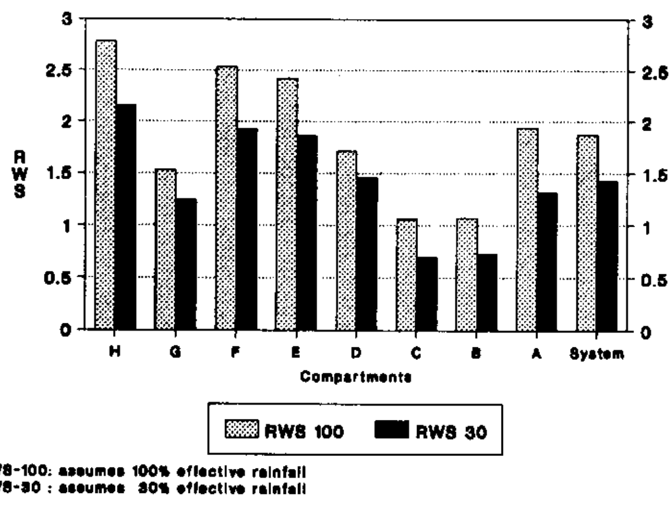
The weekly RWS values for each of the compartments were estimated (Table 10 and Figure 8) and using these values, equity in distribution among the compartments was evaluated. Adequacy of supply to demand is clearly indicated. If total rainfall or 100 percent effective rainfall is used, the average overall relative water supply for the last 3 years is approximately 1.88 which is equivalent in overall system efficiency terms to 53 percent.

Table 10. Mean weekly relative water supply (RWS), assuming 100 percent effective rainfall, the Kerian Irrigation Scheme, by compartment, 1987–1989.

Season	Compartment								Over-all
	A	B	C	D	E	F	G	H	
Off-season 1987	1.83	1.17	0.85	0	0	0	1.56	3.47	1.78
Main season 1987/1988	2.00	1.07	1.48	2.03	3.15	1.54	1.66	2.88	1.98
Off-season 1988	1.45	0.84	0.95	2.77	2.30	3.11	1.69	2.43	1.96
Main season 1988/1989	0	0	0.86	1.48	2.30	2.53	1.37	2.52	1.84
Off-season 1989	2.17	1.15	0	1.15	2.26	2.86	0	0	1.92
Main season 1989/1990	2.27	1.13	1.15	1.13	2.11	2.59	1.37	2.59	1.81
Average	1.94	1.07	1.06	1.71	2.42	2.53	1.53	2.78	1.88

Irrigation efficiency = 53 percent.

Figure 8. Relative water supply (RWS) at the Kerian Irrigation Scheme by compartment.



On the other hand, if the rainfall is assumed to be 30 percent effective, the overall relative water supply (modifying the original concept of RWS) is 1.43, equivalent to an irrigation efficiency of 70 percent which is the assumed design efficiency for the Kerian Irrigation Scheme. This latter estimate of RWS may not be realistic since there will be more weeks in which the supply is less than demand, especially in compartments B, C, D and G (Tables 8 and 11). This indicates that factors affecting supply and demand will have to be examined further.

Table 11. Mean relative water supply (RWS), assuming 30 percent effective rainfall, the Kerian Irrigation Scheme, by compartment, 1987–1989.

Season	Compartment								Over-all
	A	B	C	D	E	F	G	H	
Off-season 1987	1.24	0.88	0.67	0	0	0	1.25	2.92	1.39
Main season 1987/1988	1.45	0.68	0.92	1.72	2.30	0.85	1.52	2.16	1.45
Off-season 1988	0.99	0.59	0.59	2.50	1.64	2.29	1.36	1.87	1.48
Main season 1988/1989	0	0	0.66	1.18	1.80	1.96	1.06	1.91	1.43
Off-season 1989	1.43	0.79	0	0.91	1.86	2.38	0	0	1.48
Main season 1989/1990	1.46	0.73	0.68	1.00	1.69	2.17	0.99	1.95	1.33
Average	1.32	0.73	0.70	1.46	1.86	1.93	1.24	2.16	1.43

Irrigation efficiency = 70 percent.

On the supply side, irrigation water deliveries and the rainfall contribution or effectiveness have to be examined carefully. For example, in compartment H, it appears that the water supplied, on the average, was about twice the estimated demand. This is so even after discounting the contribution of rainfall (Table 8). This oversupply to compartment H has been acknowledged and solutions were proposed in an earlier report (Kerian Irrigation Scheme, April 1987, pp. 7 and 13). Oversight of Line Operators and the presence of a number of extra farm offtakes (illegal pipes) were the main causes for the excessive supply to this compartment.

The unmeasured drainage water reused in compartments B and C will increase the actual total water supplied. However, this amount will not exceed 50 percent of the estimated amount supplied to these compartments. With these estimates, the RWS to compartments B and C will still be lower than that of compartments E, F and H (Table 8).

On the demand side, the seepage and percolation amounts have to be accurately reckoned with, particularly in compartments B and C. Also the estimated demands for compartments D and G have to be examined further (Table 8). However, the major portions of compartments B and C which have flatter terrain and where farmers have been practicing "negative" irrigation appear to be the locations for further investigation of seepage and percolation losses. Lowering the drainage water level to 75-150 mm below the rice or *"bendang"* level as recommended, has not been fully practiced by the farmers in this area.

Without adjusting the demand, the rice fields in compartments B and C will always be submerged and this will continually decrease the soil-load bearing capacity. This will prevent the use of heavy machinery for both planting and harvesting activities. Impounded water, particularly in compartment B (Table 9), is the cause of the recurrent requests for portable pumps for draining rice fields.

The effective use of rainfall will improve with the implementation of the semiautomatic canal regulation program, in which the scheme has embarked on. To monitor rainfall in the different parts of the scheme, telemetering equipment will be used. It is envisaged that timely canal headgate closures will be attained with better responsiveness of the Gatekeepers.

Further examination of the demand in terms of seepage and percolation in each compartment will lead to a more accurate estimation of demand. The provision of batas will also lead to less on-farm loss or waste, decreasing the demand.

The supply-increasing and demand-reducing activities will lead to the optimum operation of the system. This optimum operation will be in terms of a lesser or the minimal pumping period and nondepletion of reservoir water supply. However, these activities will also correspond to an increase in the management capability of the system. Gatekeepers/Line Operators will have to be trained in the timely closing and opening of gates, and in effective maintenance and monitoring of rainfall stations in their respective areas (in places where rainfall will be manually monitored).

With regard to the demand-reducing activities, more effective and vigorous campaigns to encourage and convince farmers to build their batas and maintain proper drainage levels have to be undertaken. Empirical measurements of seepage and percolation need to be done for different soils and terrain conditions.

The other two performance indicators, the water productivity index and the cropping intensity, will be discussed in the next chapter.

CHAPTER 5

Agricultural Production

IN THE PROVISION of agricultural support services, a leading role was played by the Department of Agriculture (DOA), the Farmers' Organization Authority (FOA) and the Bank Pertanian Malaysia (BPM). The DOA took care of the extension services, the FOA assisted in the supply of inputs such as fertilizer and chemicals while the Area Farmers' Organizations (AFOs) and the BPM provided the credit. Other government agencies such as the Malaysian Agricultural Research and Development Institute (MARDI) were also involved, providing high yielding seeds and new technology.

Subsidies in the form of free fertilizer, minimal irrigation fee, low- interest credit and a guaranteed price for rice are provided to farmers. These constitute a part of the strategy to improve the income of farmers which is one of the major objectives of the rehabilitation project.

Yields at the Kerian Irrigation Scheme have been steadily increasing until the main season of 1987/1988 (Table 12). After this period, yields started to decline. Several causes such as pests and diseases, and the weather were attributed to this decline. The proliferation of the "black bug" or "stink bug" has affected some portions of the scheme. Excessive rainfall was also experienced in this season. Because of the wetter conditions, the rice was susceptible to pests and diseases reducing the yields, particularly in compartments E and F (Tables 13 and 14). This decline in yield was observed not only at the Kerian Irrigation Scheme but nationwide.

The higher production in the off-season (February-July) is attributed to the availability of more sunshine during this period (Table 12). In the main season (August-January), there are relatively more rainy days preventing the rice crop from receiving the optimum level of light energy for photosynthesis.

Table 12. Comparison of projected and actual yields (t/ha) at the Kerian Irrigation Scheme, 1979 to 1989.

Year	Main season			Off-season		
	Projected (P)	Actual (A)	A/P	Projected (P)	Actual (A)	A/P
1979	2.50	2.60	1.04	2.60	2.57	0.99
1980	2.60	2.65	1.02	2.70	2.58	0.96
1981	2.70	2.66	0.98	2.80	2.68	0.96
1982	2.90	2.68	0.92	3.00	2.75	0.92
1983	3.00	3.08	1.03	3.20	3.08	0.96
1984	3.20	3.40	1.06	3.40	3.50	1.03
1985	3.56	3.56	1.00	3.61	3.57	0.99
1986	3.65	3.32	0.91	3.73	3.59	0.96
1987	3.73	3.41	0.91	3.85	3.44	0.89
1988	3.82	2.49	0.65	3.96	2.74	0.69
1989	3.91	-2.87	0.73	4.20	2.84	0.68

Sources: The projected yields for 1979 to 1984 were taken from the Project Appraisal Report, 1978. The projected yields for 1985 to 1989 were taken from the Project Completion Report, 1987.

WATER PRODUCTIVITY INDEX

The water productivity index provides a measure of the irrigation system's effectiveness in terms of gross grain yield and the corresponding monetary value per unit volume of water applied, in this case, the gross volume of water which includes rainfall.

The water productivity at the Kerian Irrigation Scheme was estimated for each compartment for five seasons (Table 13). The water productivity index ranged from 0.035 to 0.271 kg/m^3, with an overall average of 0.12 kg/m^3.

Based on this measure, compartment C had been the most productive section of the scheme for the previous years. However, with the unmeasured surface drainage water reused in compartments B and C, the actual volume of water delivered will be higher than the measured volume. Nevertheless, it can be assumed that the unmeasured surface drainage reuse is very much less than the measured irrigation water supply.

Table 13. Total irrigation water supply (Qs), rainfall (Rn), yield (Y) and water productivity index (Wp), the Kerian Irrigation Scheme, by compartment, 1987–1989.

Compartment		Season					Average
		OS 1987	MS 87–88	OS 1988	MS 88–89	OS 1989	
A	Qs	0.892	1.095	0.726	–	0.981	0.924
	Rn	0.799	0.771	0.620	–	0.932	0.781
	Y	3874	3072	2714	–	3272	3233
	Wp	0.434	0.281	0.374	–	0.334	0.356
	Wpt	0.229	0.165	0.202	–	0.171	0.192
B	Qs	1.451	0.958	0.870	–	1.124	1.101
	Rn	0.798	1.130	1.561	–	0.968	1.114
	Y	4130	3114	2946	–	2991	3295
	Wp	0.285	0.325	0.339	–	0.266	0.304
	Wpt	0.184	0.149	0.121	–	0.143	0.149
C	Qs	1.082	1.170	0.830	1.021	–	1.026
	Rn	0.506	1.425	1.002	0.697	–	0.908
	Y	4309	3179	3529	3359	–	3594
	Wp	0.398	0.272	0.425	0.329	–	0.356
	Wpt	0.271	0.123	0.193	0.196	–	0.196
D	Qs	–	3.130	4.966	2.207	1.714	3.004
	Rn	–	1.242	1.096	0.971	0.818	1.032
	Y	–	2076	2116	2092	2125	2311
	Wp	–	0.066	0.043	0.095	0.124	0.082
	Wpt	–	0.047	0.035	0.066	0.084	0.058
E	Qs	–	1.569	1.390	1.590	1.774	1.581
	Rn	–	1.026	1.130	0.908	0.740	0.951
	Y	–	1212	2465	2219	2714	2206
	Wp	–	0.077	0.177	0.140	0.153	0.137
	Wpt	–	0.047	0.098	0.089	0.108	0.085
F	Qs	–	0.499	1.838	1.637	2.126	1.525
	Rn	–	1.028	1.092	0.933	0.806	0.965
	Y	–	1666	3521	2580	3115	2720
	Wp	–	0.334	0.192	0.158	0.147	0.207
	Wpt	–	0.109	0.120	0.100	0.106	0.109
G	Qs	2.272	2.695	2.761	2.088	–	1.886
	Rn	0.984	1.446	1.442	0.974	–	0.966
	Y	3543	2503	2762	3222	–	3007
	Wp	0.156	0.093	0.100	0.154	–	0.126
	Wpt	0.109	0.060	0.066	0.105	–	0.085
H	Qs	3.015	2.146	2.109	2.052	–	2.331
	Rn	0.946	1.201	0.951	1.030	–	1.032
	Y	3539	2130	2377	2999	–	2635
	Wp	0.117	0.099	0.113	0.146	–	0.119
	Wpt	0.089	0.064	0.078	0.097	–	0.082

Notes: OS = Off-season.

MS = Main season.

Qs and Rn are expressed in meters and Y in kg/ha.

Wp = Water productivity index in kg/cu.m.: Wp = Y / (Qs x 10,000).

This index only includes the total irrigation supplied.

Wpt= Total water productivity index (Wpt=Y/Qt x 10,000).

Qt = Qs + Rn (irrigation and rainfall).

Overall average water productivity index: Wp = 0.213 kg/cu.m.

Wpt = 0.120 kg/cu.m.

Table 14. Estimated income and mean production costs, the Kerian Irrigation Scheme, main season, by compartment 1987/1988.

Compartment	Yield (kg/ha)	Income (M$/ha)	Production costs (M$/ha)	Net income (M$/ha)
A	3,072	1,990.34	700.09	1,290.25
B	3,114	2,017.56	700.09	1,317.47
C	3,179	2,059.67	700.09	1,359.58
D	2,076	1,345.04	700.09	644.95
E	1,212	785.13	700.09	85.04
F	1,666	1,079.40	700.09	379.31
G	2,503	1,621.69	700.09	921.6
H	2,130	1,380.02	700.09	679.94
Mean	2,496	1,617.15	700.09	917.07

Notes: The price of rough rice was estimated using the rate of M$64.79/100 kg. The production costs used are the average values based on the survey conducted in 1987.

With this assumption, comparison of the water productivity indexes among compartments will be feasible. The yield and water supplied to the compartments are the major factors of this index. Compartments B and C had consistently higher average yields than compartments D, E and H (Tables 8 and 13). In terms of water supplied, compartments D and H also had consistently higher supplies than compartments B and C, even if the unmeasured surface drainage water reused amounted to 50 percent of the measured irrigation water supply.

These results indicate that there are opportunities to improve the productivity of water in all of the compartments, particularly in compartments D and H. Further assessment of water supply and demand in compartments B and C will be needed to determine the actual contribution of surface drainage to irrigation water supply.

The water productivity index provides a gross measure of the contribution of irrigation water to production through time. The values obtained are on the low side. This can be attributed more to the low yields obtained and the excessive water supply. Even without accounting for the rainfall, the overall estimated water productivity index amounted only to 0.214 kg/cu.m. (Table 13). This implies that the constraints to crop production were not due to shortage of water but to some other factors such as labor, incidence of pests and diseases, etc.

With the effective use of irrigation and rainfall and better yields, obtainable targets for water productivity from 0.3 to 0.5 kg/cu.m. can be considered. This range was estimated based on the finding that, under controlled environments, consumptive use efficiency of rice ranged from 0.7 to 1.1 kg/cu.m. (FAO 1986).

CROPPING INTENSITY

This performance indicator represents the capability of the scheme to provide irrigation water to the entire command area or portions thereof, for each cropping season evaluated within a year. However, adequacy of water supply is one of the built-in assumptions of this measure. In this study, the cropping intensity is defined as the sum of the off-season and main season areas divided by the command or service area, expressed as a percent (Table 15).

Table 15. Area planted and estimated cropping intensity at the Kerian Irrigation Scheme, 1987–1989.

Season	Area (ha)	Total (ha)	C.I.(%)
Off-season 1987	20,265		
Main season 1987/1988	23,400	43,666	181
Off-season 1988	17,939		
Main season 1988/1989	21,603	39,542	165
Off-season 1989	14,565		
Main season 1989/1990	23,360	37,925	158

Note: C.I. = Cropping intensity, defined as the ratio of the total area in a year to the actual irrigated area, expressed as a percentage.

The cropping intensity was estimated at 181 percent in 1987, when farmers did not conform to the designed cropping schedules of the compartments (Table 15 and Figures 1 and 5). However, in subsequent years, the cropping intensity declined. This was due to the reduction in area planted in the off-season. This reduction in the off-season area planted was attributed to scheduling difficulties. Farmers were not able to adhere to the cropping schedules due to various reasons. One of the reasons adduced was that farmers had to complete planting in the off-season before the onset of the month of fasting in either March or April.

PRODUCTION COSTS AND INCOME

The average rice production costs and income were estimated based on a survey conducted in the main season of 1987/1988 (Table 16). The production costs included family labor and subsidized fertilizer, which

Table 16. Average rice production costs and income at the Kerian Irrigation Scheme, main season, 1987/1988.

I Average income:	Yield: 2,134.77 kg/ha			M$/ha
	Price: 64.79 M$/100kg			
	Gross income:		...	1,383.12
II Production cost:				
(a)	Input costs:			
	i) Fertilizer	232.99		
	ii) Other inputs	69.53		
Subtotal			...	302.52
(b)	Labor and other costs:			
	i) Family labor	565.99		
	ii) Paid-out costs	438.91		
Subtotal			...	1,004.90
(c)	Various costs, land rent, etc.		...	191.65
	Total cost (a)+(b)+(c)		...	1,499.07
	less: subsidy (fertilizer) and family labor		...	–798.98
	Total paid-out cost		...	700.09
III Net income				
Gross income (I)			...	1,383.12
Productions cost (II)			...	700.09
(I) – (II)			...	683.03
Average income for the main season: 683 M$/ha x 1.471 ha =			M$	956.24
Average income for off-season:			M$	1,058.11
Total:			(M$/year)	2,014.35
			(M$/month)	167.86

Notes: Average farm size for main season, 1987/1988 = 1.471 ha; average net income for off-season, 1988, was taken from estimates made from data of the entire Kerian-Sg. Manik Project.

Source: Kerian Irrigation Project. 1988. Early findings on poverty study.

accounted for 39 percent and 15 percent of the total costs, respectively. The results obtained indicate a low net income or a low monthly income for farmers. The main reason for this is the low yield obtained as revealed in this survey. Unfortunately, the survey was conducted during the season when the rice crop yields were the lowest for the past three years. This explains to a large extent the low net income received by farmers from rice farming.

However, the low yield and the resulting net income were only observed in the Kerian Darat portions of the scheme. An estimation of the average income by compartments indicated that only farmers in some compartments had this low net income (Table 14). Compartments E and F in particular, obtained the lowest yields in this particular season. The low yield obtained was attributed to the infestation of pests and diseases and unfavorable weather conditions.

Table 17. Sources and estimated average monthly income of farmers at the Kerian Irrigation Scheme, 1988.

Source	Income M$/month	Percentage income[1]
AGRICULTURAL Rough rice	142.74	37.8
Nonrice crops	47.99	12.7
Wages	32.33	8.6
Total	223.06	59
OTHERS Nonagricultural wages	73.97	19.6
Industrial	20.6	5.5
Remitted[2]	22.2	5.9
Miscellaneous	33.1	10.1
Total	154.89	41

[1]Based on a sample survey of farmers in the vicinity of the project.
[2]Transferred income, from relatives working in other places.
Source: Kerian Irrigation Project. 1988. Early findings on poverty study.

On a yearly basis, the average monthly income derived from irrigated rice farming was M$167.86. This is very close to the figure (M$142.74) obtained in the survey of 1988 (Table 17). It appears that income from irrigated rice production only accounts for 37 percent of the total income of most farmers. About 41 percent of their income is derived from nonagricultural sources

(Table 17). Nonetheless, any incremental increase in income from rice production will definitely increase or improve the livelihood of farmers at the Kerian Irrigation Scheme. This is also an indication of the opportunities available to improve the monthly income of farmers to attain M$300 or more from irrigated rice farming as envisaged in the rehabilitation project of the Kerian Irrigation Scheme.

OPERATION AND MAINTENANCE COSTS

The operation and maintenance (O&M) budget and expenditure at the Kerian Irrigation Scheme increased substantially in 1989 (Table 18) following the increase in O&M expenditure after the completion of the commissioning works. The availability of funds from the State and the Federal treasuries to cover O&M costs helped to maintain the recommended levels of support for this activity. Considering the O&M budget item for 1989, the rate of yearly expenditure is at M$224/ha. This is below the recommended rate of M$260/ha (Kerian Irrigation Scheme. April 1987. pp.10-11).

With the implementation of the supply-demand position procedures which include the use of telemetering equipment and their maintenance, increases in expenditure are to be expected. Proper O&M will be possible only if resources are provided to achieve the objectives of the scheme and ultimately of the project, by 1993.

Table 18. Operation and maintenance budget and actual expenditure at the Kerian Irrigation Scheme, 1987-1989 (in M$).

Item	Budget	Expenditure	Budget	Expenditure	Budget	Expenditure
General administration and finance	262,550	207,486.37	288,950	197,354.80	209,343	194,192.21
Irrigation operation and maintenance	2,911,323	2,995,585.87	2,557,305	2,253,116.33	5,678,535	4,936,906.45
Additional maintenance*		27,503		36,905		97,086
Administration for maintenance	85,150	73,740.67	58,940	57,638.96	168,240	56,162.73
Irrigation development	105,120	97,111.19	104,660	103,450.48	105,228	97,568.79
Total	3,364,143	3,401,427.10	3,009,855	2,648,465.57	6,161,34	5,381,916.18
Yearly O&M expenditure per unit area		142		110		224
Yearly O&M costs per unit volume of water		0.0051 M$/$m^3$		0.0044 M$/m3		0.0093 M$/$m^3$

*Portion of commissioning expenditures directly related to regular maintenance activities of the scheme.

RECOVERY OF O&M COSTS

The water rates are covered by the Irrigation Areas Ordinance of 1953. However, it is up to the individual States to levy the maximum and minimum charges based on the various classes of land in the gazetted areas. The State of Perak has a lower rate of irrigation fee than the State of Penang (Table 19).

With these rates, the collection at the scheme averaged 73 percent of total dues for the years 1986/1988 (Table 20). The amount collected represented approximately 9 percent of the O&M expenditure of the scheme for 1988 (Table 18). The water charges are collected by the Land Revenue Office of the State. The water rates are low compared to the capital costs and recurring O&M costs. However, because of social and economic factors benefiting the farmers, the rates have not been changed.

With these low water rates, the capital and yearly O&M costs can be considered as an additional subsidy to the farmers. This additional subsidy is estimated to average to 0.0063 M$/m^3/yr, exclusive of the water rate paid by the farmers (Table 18).

Table 19. Water rates in the States of Perak and Penang.

Land classification	Water rate (M$/acre/annum)	
	Perak	Penang
Class A, yield more than 2,370 kg/ha/crop	4.50	6.00 (S) 9.00 (D)
Class B, yield between 1,485 and 2,370 kg/ha/crop	3.00	4.50 (S) 6.75 (D)
Class C, yield less than 1185 kg/ha/crop	1.00	3.00 (S) 4.50 (D)

Notes: (S) = Single crop
(D) = Double crop
1989 Exchange rate: US$1.00 = M$2.66

A suggestion has been made that the present maintenance work provided by the farmers be considered as a payment or contribution to the O&M costs of the scheme. This is in view of the token and low collection rate of the irrigation fee paid by farmers to the State Land Revenue Office (Table 20). The maintenance work done by the farmers and paid for by DID is substantial (Table 6). If this suggestion is implemented, farmers will make a large contribution to the maintenance of the scheme.

Table 20. Land and water charges (M$) at the Kerian Irrigation Scheme, 1986–1988.

Type of charges	1986	1987	1988
Land charges			
Total due	2,571,417	2,606,645	2,804,522
Collection	1,739,476	1,743,921	1,801,808
Collection %	68	67	64
Water charges			
Total due	249,606	261,320	249,637
Collection	171,959	197,119	186,591
Collection %	69	75	75

Note: Land and water charges are collected by the State Land Revenue Office.

CHAPTER 6

Design-Management Interactions and Effects on Performance

PROJECT DESIGN AND ACTUAL MANAGEMENT

THE ORIGINAL DESIGN of the scheme was based on the objectives of attaining a cropping intensity of 190 percent and increased yield by 1993. To achieve these objectives, the scheme was designed to provide irrigation water supply at the right time, right place and right amount by following a designed cropping schedule. To operationalize this, measurement and control structures were to be provided down to the tertiary-canal level; this would provide, on the average, one offtake for every two farm lots.

Measurement and control were to be provided by Constant Head Orifices (CHOs) at the secondary and tertiary offtakes. These structures were to combine measurement and control effectively, provided the water levels in the canals were relatively stable or less fluctuating and the trained field staff could manipulate the CHO gates properly. Approximately, 620 CHOs were built to provide this capability.

However, with fluctuating canal water levels, field staff have encountered difficulties in adjusting the downstream gates to maintain a constant differential head between the water levels of the canal and the CHO chamber. In some cases, even the minimum differential constant head of 6 cm was not attainable to effectively make use of the CHOs as measuring structures.

This was exacerbated by the turbulence caused by the small CHO chamber of small-diameter pipe, darkness in the chamber, and small differential head observed in some of the CHOs. All these defects contributed to the difficulties encountered by the field staff in adjusting the CHO gates properly and regularly.

Because of these difficulties, the Line Operators/Gatekeepers were able to effectively measure and control CHOs only at the main canal and secondary canals. The adequacy of discharge of tertiary canal CHOs was estimated through experience and visual observation. Gatekeepers' experiences of appropriate gate settings were used as the operating procedure for this estimation of water adequacy.

In addition to the CHOs, control gates from the reservoir, main canal cross-regulators, irrigation and drainage end controls, and tidal gate controls have to be effectively operated by the Gatekeepers.

Table 21. Rectification works by the Commissioning Teams, as of June 1990.

Compartment	Work item				
	Reduction of farm offtake size	**Removal or closure of illegal pipes**	**Installation and adjustment of stick gauges**	**Modification of sill levels for structures**	**Provision of direct frontage in supply or drainage**
A Target	9	56	106	20	1,187
Completed	11	34	237	16	–
B Target	20	59	323	17	1,939
Completed	20	7	390	16	–
C Target	50	144	291	20	100
Completed	96	96	301	4	80
D Target	25	244	278	2	125
Completed	88	250	338	12	100
E Target	180	126	169	2	296
Completed	180	103	205	7	260
F Target	224	247	66	13	261
Completed	472	257	193	19	249
G Target	84	91	212	41	95
Completed	84	93	390	41	110
H Target	557	230	312	65	130
Completed	557	216	312	66	130
Total: Target	1,149	1,197	1,757	180	4,133
Completed	1,458	1,056	2,366	181	929
% Progress	129.5	88.5	134.6	100	22.48

Note: Except for the provision of a direct frontage (which is in acres), the rest of the work items are in terms of the number of units.

With the provision of transport (as should be the case) to the field staff (IIs, IOs and Gatekeepers) (Table 4) opening and closing of gates are facilitated. As officially recorded, the Gatekeepers travel about 17 km daily to operate 20 gates. In practice, the minimum number of gates operated is 2 (in case of tidal gates) and the maximum 42 (in the case of CHOs which are close to one another in secondary canals). For some gates, weekly settings are sufficient, provided no adjustments are needed (i.e., no rainfall occurs and constant discharge or supply in the main canal is maintained). However, with the increasing effort to effectively utilize rainfall, more frequent operation of the gates will be required, especially in the rainy months.

At the tertiary-canal level, direct access or frontage is one of the demands of the farmers. Instead of two farm lots sharing one offtake, one access for each lot is now being considered. So far, only 1,297 ha or 6 percent of the total area is not provided with a frontage. Extra offtakes or illegal pipes have been removed or closed. A summary of the status of the commissioning works indicates the completion of facilities even at the tertiary level (Table 21).

Although designed and built to be operated with measurement and control down to the tertiary-canal level, these design objectives were overridden by practical considerations which became the basis for managing the scheme. Although the DID field staff were trained to measure and control CHOs, it was not felt practical to do so at the tertiary level. Water savings to be generated in more intensive measurement and control were not deemed critical enough to invest in resources.

The motivation to undertake intensive measurement in the tertiary canals was not made clear or obligatory to the field staff. This was exacerbated by the nonadherence of the farmers to the cropping schedules. Unless the consequences of intensive measurement and control are understood and internalized by the DID field staff, it will be difficult to improve the present level of performance of the scheme.

Design shortfalls can be attributed to the managemertt assumptions made for the rehabilitation of the scheme, particularly in the use of CHOs and in the planned cropping schedules. In this case, the design was appropriate but the assumptions made in the management of the facilities fell short of the projections. The field staff and the farmers were not able to cope with the projections made in the design of the scheme. The design interactions and the ensuing actual management of the scheme resulted in the observed and estimated indicators of scheme performance.

One can also argue that the management skills assumed for the proper use of CHOs were not provided. However, with the resources available at present, training and motivation of field staff to carry out intensive measurement at the tertiary canals is neither practical nor urgent as far as the DID field staff is concerned.

On the other hand, farmers have their management obligations to fulfill in making optimal use of the irrigation water provided to them. Design assumptions, where farmers were expected to adhere to the cropping schedules, build field ridges and level their fields, were found to be lacking in most of the compartments. However, manifestations of the design and management interactions attributable to farmers have influenced the performance of the scheme, particularly in the cropping intensity of the sclieme.

With the "manage-as-planned" program to be undertaken, training and motivation of the field staff have to be undertaken too. Training will be necessary in the timely closing and opening of gates so that rainfall can be used effectively. Motivation to do so on a regular basis will be needed to sustain whatever improvements already achieved.

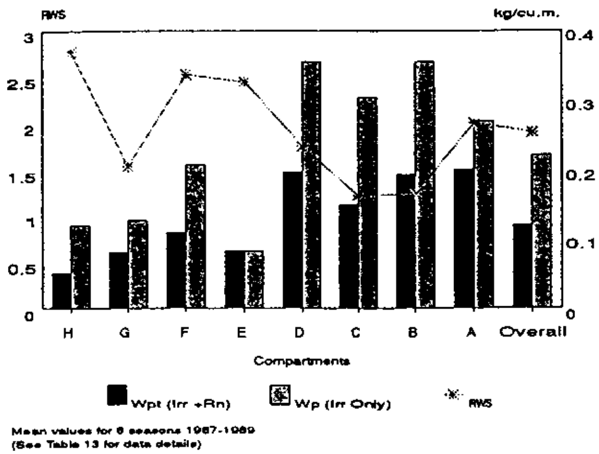
The field staff will have to exert more effort and time to encourage and convince farmers of the importance of adhering to the cropping schedules.

EFFECTS ON PERFORMANCE

The performance of the scheme in terms of the relative water supply (RWS) indicates that there are opportunities wherein improvements can be made. In terms of equity, better distribution can be attained if better monitoring and control are undertaken. This is particularly true in the case of compartment H (Table 10 and Figure 9). The appropriate monitoring and control of the Selinsing Canal will lead to effective use of the water supply. The RWS values indicate that the upstream compartments, particularly E, F and H, were provided with more than twice the demand, on the average, for the last six seasons.

The inequity of water distribution did not, however, bring about a decrease in yield due to inadequate or undependable water supply. The inequity is more in terms of excessive supply to some parts of the scheme. The inadequacy and unreliability of water supply were compensated by the Bogak Pumping Station and also to some extent by the mobile pumps.

Figure 9. RWS and the productivity index at the Kerian Irrigation Scheme by compartment .



The compartments were ranked in accordance with the RWS and productivity index (Table 22 and Figure 9). To encourage excellent field-staff performance, a competition was organized among compartment field staff. This ranking might be considered as an additional criterion for the competition. Only compartments C and H received similar ranks for both RWS and productivity index. This comparison shows the effects of the different factors affecting irrigation water and yield. For the RWS, the factors affecting supply and demand determine the level of performance, while for the productivity index, the total water delivered and yield determine the productivity level. However, the management of the scheme affects both these measures.

The agricultural productivity of water at the Kerian Irrigation Scheme can be increased. If the assumed effective rainfall is at 30 percent, then the productivity index increases to 0.162 kg/m^3 or a 40 percent increase in productivity. If the yield increases and lesser water is delivered, the productivity of irrigation water and of the scheme will undoubtedly increase. With the facilities and resources available at the Kerian Irrigation Scheme, the potential of attaining a productivity index of 0.3–0.5 kg/m^3 is a realistic objective to be achieved in the coming years.

Table 22. Ranking of compartments by the mean relative water supply (RWS) and the mean productivity index at the Kerian Irrigation Scheme, 1987–1989.

Compartment	RWS	Rank	Productivity index	Rank
A	1.94	5	0.192	2
B	1.07	2	0.149	3
C	1.06	1	0.196	1
D	1.71	4	0.058	8
E	2.42	6	0.085	6
F	2.53	7	0.109	4
G	1.53	3	0.085	5
H	2.78	8	0.082	7

Note: The estimated mean RWS and the productivity index include rainfall.

CROPPING SCHEDULES

The cropping pattern has been divided into three schedules. However, the three groups of compartments do not match these schedules (Figures 4 and 8). Adherence of farmers to the schedules is not solely due to the availability of irrigation water supply as scheduled, but is also dependent on the availability of other production inputs (i.e., labor, seed, fertilizer, etc.) and also on the willingness of the farmers to follow the schedules. A concerted effort on the part of the project staff (Department of Irrigation and Drainage, Department of Agriculture, Farmers' Organization Authority, Bank Pertanian Malaysia, etc.) will be necessary to convince the farmers in all of the compartments of the importance of adhering to the planned cropping schedules.

However, alternative arrangements should be explored in case the planned cropping schedules are not feasible given the limitations of the institutional (Department of Irrigation and Drainage, Department of Agriculture, etc., and farmers) and structural (canals, control structures, pumping station, FDCs, etc.) capabilities of the scheme. Other cropping schedules can be considered as long as irrigation water supply is optimized and the cropping intensity is increased to the attainable potential. A cropping intensity of 181 percent has been attained without conforming to the planned schedules (Table 15). This indicates that an alternative cropping schedule can attain the same objective of increased cropping intensity.

Another performance indicator is the cropping intensity. The area planted in a year provides an indication of how effective the management of the scheme has been not only in being able to provide an area with irrigation water but also in convincing the farmers of the importance of planting according to the planned schedule. However, this measure does not indicate the level of adequacy, reliability or equity in water supply. In the absence of a more comprehensive indicator incorporating adequacy, reliability and equity, the cropping intensity is still a functional indicator of performance.

A more consistent definition of the cropping intensity should be used. The calendar year — and not the cropping year — should be used as the basis of the cropping intensity in order to make the latter assessment more consistent. The cropping seasons shift depending on when the farmers are actually able to plant. If a calendar year is the basis, as long as the total area planted in the calendar year is monitored, then regardless of the cropping seasons, a consistent basis for the cropping intensity will be established.

At the Kerian Irrigation Scheme, the capability of increasing the cropping intensity has been demonstrated even without strictly following the planned schedules among compartments. However, farmers' adherence to the cropping schedules is the critical component that will determine further increases in the cropping intensity. Ultimately, it is the farmers who have to decide whether to properly utilize the irrigation water delivered to them or not. Motivating farmers to adhere to the cropping schedules will have to be a part of the activities of DID if increasing the cropping intensity is to be a realistic objective in the coming seasons.

PROFITABILITY OF RICE PRODUCTION

For rice production to become profitable at the Kerian Irrigation Scheme, yield and area farmed will have to be increased. Production costs have to be reduced or made cost-effective. There is an indication of labor scarcity due to the availability of better income opportunities away from farming. This is indicated by the average age of farmers in the scheme which is 52 years (Table 23). This and the scarcity of rural labor will increase labor costs. Labor availability is one factor which might be more limiting than water availability in increasing production. Mechanization is an alternative but conditions for its effectiveness will have to be carefully considered.

Table 23. Age distribution of heads of farm households at the Kerian Irrigation Scheme, 1988.

Age group (years)	Male		Female		Total	
	n	%	n	%	n	%
< 30	26	5.3	0	0	26	5.3
30 – 49	159	32.2	12	2.4	171	34.6
50 – 64	181	36	34	6.9	215	43.5
> 65	70	14	12	2.4	82	16.6
Total	436	88.3	58	11.7	494	100
> 50	251	57	46	79	297	60

Average age: 51.9 years
Source: The Kerian Irrigation Project. 1988. Early findings on poverty study.

To increase profitability, the area farmed can be increased. The data show that there is an upward trend in the farm size. This is indicated by the increase in the number of owner-tenants (Table 2). Another indicator is the increase in rice farm size from 1.33 ha in 1978 to 1.47 ha in 1988. Although this is marginal, it is necessary for farmers to increase the farm size to make irrigated rice farming profitable. Although rice farming constitutes only 37 percent of the source of income, any increase in this source will definitely improve the overall livelihood of the farmers.

Good water control is necessary to make mechanization feasible. Proper drainage will have to be observed to improve the load-bearing capacity of soils, particularly in the Kerian Laut compartments, and proper leveling will have to be done in the Kerian command areas.

EFFECTIVENESS OF RAINFALL

The effectiveness of rainfall is dependent on the period or time of occurrence and amount retained in the rice field. In this study, rainfall was considered only when it coincided with the release of irrigation water to each compartment. Its effectiveness ends with the start of the suspension of irrigation water delivery or start of the drainage period before harvest.

The absence of data on the average height of field ridges or dikes makes the accurate estimate of effective rainfall difficult. For rainfall to be considered effective, its depth should not exceed the height of the field ridges or dikes.

The design rainfall effectiveness of 30 percent was not used since there would be a longer period in which the demand exceeds the supply in four compartments, and particularly in compartments B and C. However, if the 30 percent effective rainfall is used, the scheme will have a 70 percent irrigation efficiency (Table 11). This coincides with the assumed design efficiency in the appraisal stage of the rehabilitation project for the Kerian Irrigation Scheme.

However, a better criterion should be adopted to properly assess the contribution of rainfall to irrigation. The objective of an effective irrigation management is the optimum utilization of rainfall for irrigation. With the resources in terms of manpower and structural facilities available, the use of rainfall for irrigation will definitely contribute to the reduction of pumping hours and the prevention of storage depletion in the reservoir.

At present, a network of rain gauges maintained by about 18 rainfall stations monitor the amount of rainfall and the spatial distribution within the scheme. This density of rainfall stations, averaging two to three stations per compartment, is useful in making better estimate of rainfall in each compartment. Some of these stations are automatically monitored and data used in the daily water balance estimation for the 'manage-as-planned' procedure.

With the supply-demand position plan for the Kerian Irrigation Scheme and the telemetering capability, effective rainfall can be properly estimated and fully utilized. Accurate monitoring and responsive operation of gates will be the key elements necessary to make optimum use of rainfall. Furthermore, this plan for the effective use of rainfall will reduce the operation of the Bogak Pumping Station. Additional effort on the part of the field staff will be necessary to carry out this plan of effective use of rainfall.

CHAPTER 7

Opportunities for Improvement of System Performance

DESPITE THE RELATIVELY satisfactory levels of performance of the scheme in terms of the overall relative water supply and the cropping intensity, there are opportunities to improve system performance.

SUPPLY INCREASING ACTIVITIES

The effective use of rainfall through the utilization of the telemetering equipment and responsive efforts of the field staff constitute one area for improvement. This will increase the utility of rainfall and reduce the necessity for supply from the reservoir and the Bogak Pumping Station. However, financial and manpower resources will have to be invested to attain this improvement.

Improving the equity of distribution through the timely closing and opening of gates will reduce distribution losses at the secondary and tertiary canals.

This is pertinent to compartments E, F and H where more than twice the demand was observed in the last three years or six seasons.

Raising the height of the reservoir perimeter bund will increase the live storage capacity. This will help prevent water shortage and also provide an additional area of about 1,000 ha to the scheme. This is being considered for the next irrigation development program.

Calibration of the Bogak Pumping Station will improve the supply conditions at the Kerian Laut compartments. The pumps should be calibrated to accurately determine the discharges at low and full supply levels at the inlet side of the pump. With accurate measurements, proper estimates could be made regarding the volume of water to be pumped thereby reducing the pump operating hours.

In these supply increasing activities, only the planned increase of the reservoir capacity appears to be not directly related to the aspect of design-management interactions for improving the performance of the scheme. Effective rainfall management requires the existing controls as provided by the design of the scheme and management, the operation of the gates based on the monitored rainfall, and water adequacy status of the farms.

Equity in water supply distribution is also a function of design and management. The existing facilities for measurement and control provide a level of manageability in the scheme. The plan for equitable distribution and its actual implementation through the DID field staff will contribute to the improvement of performance at the Kerian Irrigation Scheme. Directly related to this is the proper operation of the Bogak Pumping Station. With proper calibration, accurate estimates of supply can be provided to the downstream portions of the scheme.

DEMAND REDUCING ACTIVITIES

Accurate demand assessment is necessary to avoid excess water deliveries. For compartments B, C, D and G, the pre-saturation, seepage and percolation demands should be empirically determined. Data analyzed for this study indicate that in these compartments, the pre-saturation requirements should be decreased and that the percolation requirement should be further examined. The existing practice of "negative" irrigation or drainage water reuse will have to be further assessed in compartments B and C. The trade-offs will be in terms of less water to be supplied as against maintaining continually flooded rice fields which both prevent the use of mechanized implements and provide an environment conducive to the breeding of pests and the spread of diseases.

The implementation of appropriate farm-level practices such as providing batas, i.e., field ridges, and leveling rice fields will contribute to the reduction of demand. Actually, the construction of field ridges is covered by the Irrigation Areas Ordinance of 1953 according to which farmers are obliged to build these ridges with the provision of penalties for noncompliance.

Reward is always better than punishment when it comes to motivating farmers to change.

The concerted effort of the staff of all the integrated agencies involved in the scheme should be exerted in encouraging or even rewarding farmers to build their field ridges. Rice-field leveling needs further assessment if the labor or additional support from the agencies is to be provided. If water control is to be achieved to save water and bring in mechanization, leveling of rice fields will have to be undertaken.

As these demand-reducing activities are directly related to the interactions of design and management there is a need for the accurate assessment of physical demands and farmers' demands. The assumptions in the design of the scheme have to be verified and modified accordingly. These assumptions are in regard to the seepage and percolation values used to determine demand. In compartments A, B and C, in particular, the results of the analysis showed that seepage and percolation values might be minimal in some cases and even negative, which might be due to the contributions of overland and subsurface drainage water. Thus, an accurate assessment of the seepage and percolation will lead to the improvement of performance of the scheme through decreasing the amount of water pumped and the saving of water in the reservoir.

The design of the scheme assumed farmers' cooperation in leveling the fields and the building of field ridges as mandated by the Irrigation Ordinance. However, this assumption was proven wrong in the case of the Kerian Irrigation Scheme. In the absence of leveled fields and field ridges, less water is stored in the rice plots which is drained out without being reused downstream. This aspect is more related to farmers' water management rather than to DID's management of the scheme, but somehow it contributes to the overall performance in terms of effective water use and demand.

MONITORING AND EVALUATION ACTIVITIES

Daily monitoring (including proper recording) of canal flows at the main, secondary and selected tertiary canals will have to be implemented. The tertiary canals selected from each compartment should represent or be samples of areas difficult to be irrigated or easily flooded. Monitoring at this level will provide the Irrigation Inspectors and Irrigation Overseers more accurate information on the adequacy of irrigation water. Weekly determination of the volume of discharge will facilitate evaluation and decision making. Most of these activities will be undertaken when the telemetering equipment becomes operational and the supply-demand plan is fully implemented. The monitoring activities also provide for the evaluation of the performance of the field staff. This will contribute in motivating the field staff to perform their tasks more effectively.

The water budgeting exercise as called for by the supply-demand plan evaluates the status of the supply and demand daily. However, weekly and monthly targets have to be evaluated accordingly. Moreover, evaluation of seasonal targets or objectives will have to be carried out to determine if the scheme is attaining its objectives.

Another form of evaluation that will help improve the performance of the scheme is the evaluation by farmers. Social indicators will be useful in seasonally assessing the system performance. Data of these indicators can be gathered through the AFO and the AJKKK meetings. There may be other fora where farmers can evaluate the performance of the system at the end of every season. Responding to farmers' valid evaluations will go a long way in attaining better cooperation and rapport, leading to the improvement of system performance. Difficulties regarding farmers' nonadherence to the cropping schedules and noncooperation in the building of field ridges will be minimized.

The monitoring and evaluation activities directly relate to the interactions of design and management. Monitoring not only of the flows, but also of activities of farmers and the DID field staff can contribute to the improvement of system performance. Design assumptions of field staff operating gates properly and farmers adhering to the cropping schedules will be realizable with these monitoring and evaluation activities. Ultimately, these activities will further improve performance and fulfill the objectives of the scheme.

CHAPTER 8

Conclusions

THE REHABILITATION DESIGN of the Kerian Irrigation Scheme had some shortfalls which were primarily due to the overly optimistic management assumptions used in the design. These assumptions were that the field staff would be able to cope with canal water-level fluctuations, properly adjust the CHO gates, particularly in the tertiary canals, and that the farmers would adhere to the planned cropping schedule.

The field staff relied mostly on their experiences in estimating water adequacy based on "eye-ball" readings. With only secondary canal flow measured and estimates based on experiences used at the field level, the result was the inaccurate assessment of demand and supply.

The interactions of the design and the actual management of the irrigation facilities, particularly in regard to the resulting difficulties of the field staff in measuring flows in the tertiary canals using CHOs, contributed to the overestimation in all of the compartments, with the upstream compartments G and H receiving more than twice the estimated demand. The undesirable behavior of both the field staff (negligence of Line Operators) and the farmers (illegal tapping, unnecessarily opening farm offtakes and not maintaining field ridges) can also be cited as contributing to the inequitable distribution among compartments.

With an assumed low effective rainfall (30%), the estimated overall relative water supply of the scheme can be as much as 1.43 or an irrigation efficiency of 70 percent which can be considered high. However, opportunities to improve on the effective use of rainfall, to reduce pumping costs, and to save water in the reservoir will have to be considered carefully. The "manage-as-planned" procedure or the supply-demand plan recently started in the scheme is one way of attaining this objective.

With the semiautomatic monitoring and control system to be undertaken, proper training and motivation of the field staff have to be established. These improvements in the management of the scheme are geared toward adjusting or coping with the shortcomings of the design of the scheme.

The other aspects of the design and management interactions involved water allocation of which a major portion was crop scheduling. The design of the scheme also assumed that farmers will be provided with adequate and timely water supply and inputs for production and that they would adhere to the cropping schedule as planned. With the delayed arrival of irrigation water supply for land preparation, in some cases due to misuse of irrigation and farm-level facilities, the cropping schedule was not followed. This resulted in lower cropping intensities. The Commissioning Teams have alleviated constraints related to the inadequacy of irrigation facilities and farm offtakes. These teams have also reduced unauthorized access to canals.

However, despite the nonadherence of farmers to the planned cropping schedule a high cropping intensity of 181 percent was attained in 1987, but it has been declining ever since. Farmers' indifference to the cropping schedule was traced generally to the decreasing interest in irrigated rice farming. The declining interest in irrigated farming, in turn, can be attributed to the low profitability of rice farming. With only about 37 percent of the total income of farmers coming from rice production, it is reasonable to expect farmers to spend less time for farming activities. Unless irrigated rice production becomes profitable enough it is doubtful whether irrigation system performance can be improved, or whether farmers will spend more time in proper farming activities.

The regular monitoring and evaluation activities to improve performance are applicable both to the DID field staff and to the farmers. The irrigation water supply by the DID field staff has to be monitored to ensure adequate and timely water supply to farmers' fields. The farmers, on the other hand, should also provide an evaluation of the system performance besides the complaints expressed or sent to the DID staff or to other government agencies. With this additional evaluation, a more comprehensive assessment of scheme performance will be possible.

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