CHAPTER 10

Performance of New Irrigation Settlement Schemes: A Case Study from Kirindi Oya, Sri Lanka

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OUR OVERALL ANALYTICAL approach is drawn from systems theory (IIMI 1988b, 83). In a hierarchial view of an irrigation system, at the first level, it is an irrigation water conveyance and delivery system, consisting of the physical infrastructure of canals and gates, the irrigation agency personnel who operate they system and deliver water, and the farmers who receive water and grow crops. At the second level, it is an irrigated agricultural production system. The farmer, who is the producer, makes decisions, obtains credit, procures labor, combines these inputs with water and land, and finally produces the crop. He markets much of it and seeks to improve his well-being with the resulting economic benefits. At the third level, there is the socio-political-economic system in which the other two systems are embedded. The social values, beliefs an attitudes, along with the various organizations, provide the basic framework for the behavioral patterns of the system. These systems are also embedded in the wider environment with its natural, economic, social, and other dimensions.

As we go higher in the hierarchy of systems from the first level onwards, the complexity of the systems and the interactions increase, the proportion of hardware in the system decreases, and the degree of control and capacity to manipulate the system decreases.

The system has many attributes and characteristics: the scale, size and variety of the components such as the canals, structures, soils and crops; the complex interactions among water, fertilizer, crops, prices, markets and behavior patterns; the dynamic nature of the processes — no two seasons are alike; the effects of uncertainties — hydrologic, economic and political; the multiplicity of persons making decisions at

* This paper is the product of the work of many people. Dr. P.S. Rao was the project leader for this work during most of the period of implementation and contributed a lot to the research and to our own thinking about the project. Our research officers, especially P.G. Somaratne and B.R. Ariyaratne, gathered much of the data and assisted in its analysis and interpretation. Dr. Masao Kikuchi also contributed some important suggestions. The authors are extremely grateful to them and to the staff of the management agencies for their close cooperation.

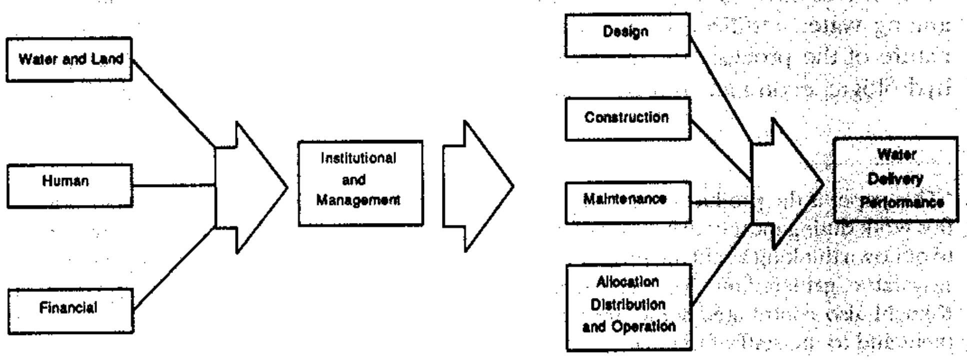
various levels; the competitive nature of resource allocation situations, especially in the context of large-scale public systems serving a large number of beneficiaries, many of them newly settled.

We use "performance" in a simple way, to refer to outputs at various levels and in various time frames. Performance is measured by comparing the degree to which the specified outputs match the specified objectives. It is important to distinguish, conceptually, "short-term performance" from "long- term performance." If managers take a short-term view, for example satisfying water users clamoring for water during a particular season regardless of the long-term implications, or maximizing short-term profit at the expense of long-term market share (as some U.S. firms are accused of doing), then the system may veer "off track" in terms of its long-term objectives and its sustainability. If the long-term objectives are the primary rationale for decisions, then very different decisions may be taken.

The performance of an irrigation project is governed by many factors, ranging from policy and planning decisions at the national level to the operation and management decisions at the farm-gate level. This paper focuses on the performance of the water conveyance and delivery system in a new irrigation settlement project. It examines the interplay between the policy, planning, and management decisions made at the national, project, and subsystem levels, and how they influence the water delivery performance of the Kirindi Oya Irrigation and Settlement Project in southern Sri Lanka. A major theme is the likely impact of decisions made to achieve short-term objectives upon the long-term sustainability of the system.

Figure 10.1 provides a schematic representation of the factors affecting the water delivery performance of a system. The water delivery performance itself is analyzed using the concepts of reliability, adequacy, and equity. The adequacy of water supply is characterized by the Relative Water Supply (RWS) parameter while equity is expressed through the Water Delivery Performance (WDP). Explanations of the observed patterns of reliability, adequacy, and equity take us back through the factors identified in Figure 10.1. Analysis of the performance of the whole project would have

Figure 10.1. Schematic representation of the factors affecting the water delivery performance of an irrigation system.



to go beyond the water delivery system, but is outside the scope of this paper, though not of our research. The water delivery system performance is crucial for the performance of the larger project.

CHARACTERISTICS OF NEW IRRIGATION SETTLEMENT PROJECTS

In many developing countries, population pressure and a desire to attain self-sufficiency in food, fiber, and shelter have led to a strategy of spreading the available resources and developmental activities very thinly among the population. This is the case in irrigation settlement projects in Sri Lanka, where many families are eligible for settlement in such projects. In many new irrigation settlement projects, some form of irrigation has already been in existence, either through diversion structures such as anicuts or through tanks. These areas are here referred to as old areas to distinguish them from the newly settled areas (new settlements) after the construction of the irrigation project.

Several unique problems of such new irrigation settlement projects can be identified. These include: water allocation conflicts between old areas and new settlements; a mismatch between assumed design and actual water requirements, especially in the early years; behavior patterns of new, often inexperienced, settlement farmers; and planning and implementation of the project by officials. These problems will be illustrated below with data from Kirindi Oya.

THE KIRINDI OYA IRRIGATION AND SETTLEMENT PROJECT[56]

Overview

In collaboration with the implementing agencies, IIMI undertook a study in the Kirindi Oya Irrigation and Settlement Project (KOISP) to identify, through field-level research, means of increasing the use of existing land, water, and infrastructure resources through improvements in the processes of design, system management, and operation and maintenance, paying particular attention to the requirements of crop diversification. The Asian Development Bank (ADB) is supporting this research. The specific objectives of the study are to identify key organizational and management factors that influence the performance of irrigation systems and the interaction between the dominant factors and selected physical characteristics of the irrigation system; and to investigate appropriate on-farm water management for diversified crop cultivation. Several reports and publications are now available on this and other IIMI research in the Kirindi Oya Project (IIMI 1988a and b; 1989a and b; 1990; Stanbury 1989; Merrey and Somaratne 1989; Sally et al. 1989; IIMI 1990).

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[56] This paper discusses the situation as of mid-1989; there have been important changes since that time, to be reported elsewhere. IIMI is research continues at present in an "action research" phase to test and adapt management innovations in close collaboration with the implementing agencies.

The Kirindi Oya Project is being developed with financial assistance from ADB, Kreditanstalt fur Wiederaufbau (KfW) and the International Fund for Agricultural Development (IFAD). The project envisages the augmentation of irrigation water supplies for the existing irrigation systems (Ellagala and Badagiriya) covering about 4,500 ha, the provision of irrigation facilities through right bank (RB) and left bank (LB) main canals from the newly-constructed Lunuganwehera Reservoir for an additional area of approximately 8,400 ha, and the settlement of about 8,320 families on the newly irrigated lands (Figure 10.2). Increasing food production for the country and providing employment through the settlement of landless people are important national objectives.

Under Phase I of the project, the reservoir at Lunuganwehera was commissioned in early 1986, and new and improved irrigation facilities were provided for 8,775 ha, of which 4,584 ha were already under cultivation with existing tanks supplied through an anicut. Phase II construction, with ADB financial assistance, commenced in 1987 and is intended to develop an additional 4,100 ha of new land.[57] The phasing of the project was necessitated by large cost overruns and time delays, forcing the Government of Sri Lanka to seek additional assistance from the ADB.

The climate of the project area is tropical and is characterized by year-round high temperatures (26° to 28°c). Evaporation is uniform throughout the year, with an annual average of 2,100 mm/year. Mean annual rainfall is 1,000 mm; the *maha* season (October to February) rainfall is approximately three times higher than the *yala* season (March to August) rainfall. Soils in the project area consist of well-drained reddish brown soils (RBE) in the upland and intermediate zones, and poorly drained low humic gley (LHG) soils in the lowland areas. Annual water availability per hectare is in the order of 2.3-2.6 m/ha. Compared with other settlement schemes in Sri Lanka, for example Mahaweli System B with an annual availability of about 3.2 m/ha, this is

Table 10.1. Recommended cropping pattern for KOISP.

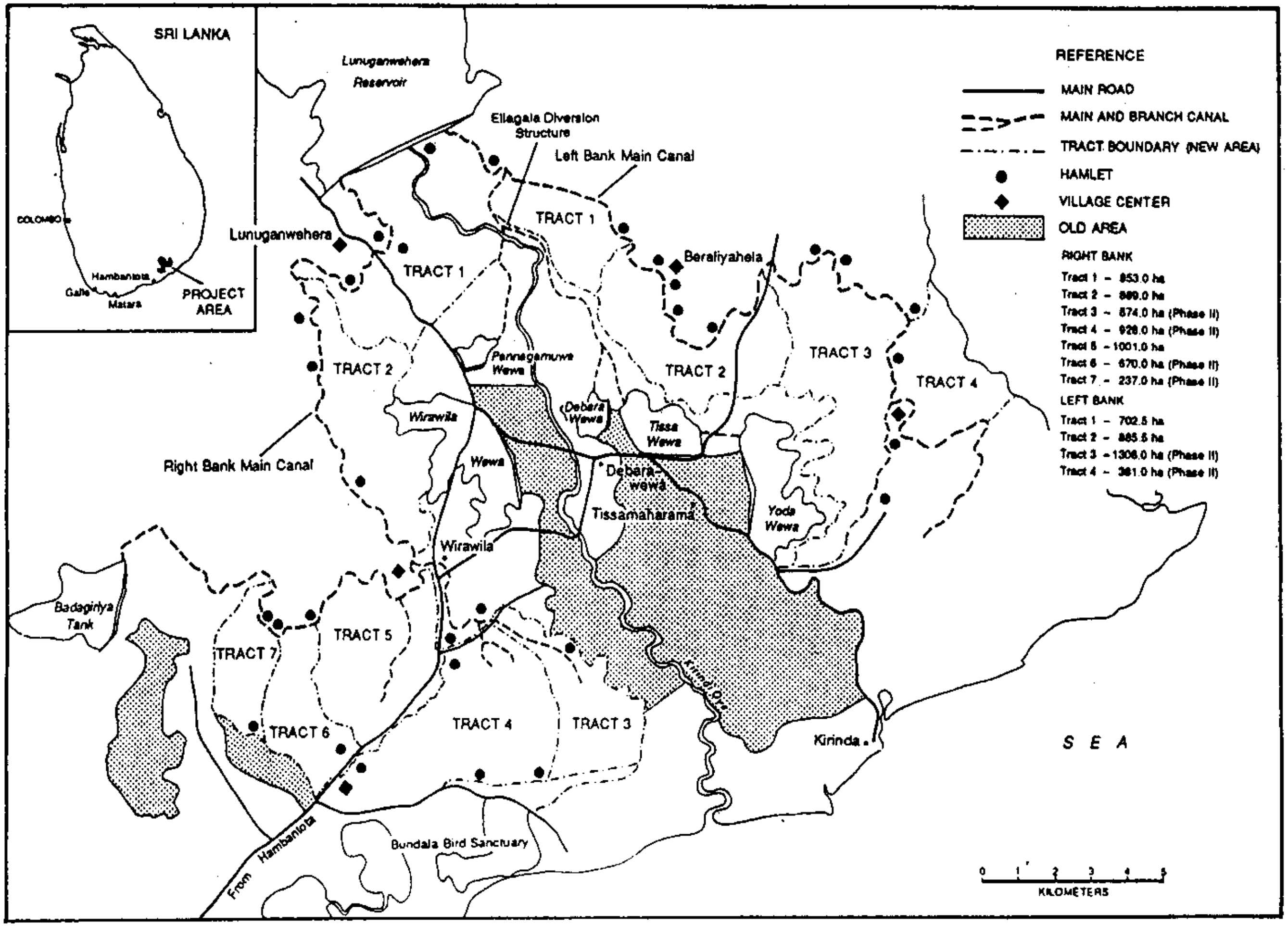
Soil type	Maha season	Yala season
Lowland	100% rice	50% rice 50% OFC
Intermediate	80% rice 20% OFC	20% rice 80% OFC
Upland (well-drained)	20% OFC 60% upland rice 20% lowland rice	100% OFC

Notes: Lowland rice is ponded rice; upland rice refers to varieties that are dry-sown.
OFC = Other field crops

Source: ADB (1986).

[57] In 1990, work on Phase II expansion was discontinued because of doubts about the water supply.

Figure 10.2. Kirindi Oya Irrigation and Settlement Project.



quite low. The project is therefore designed to spread the water thinly over a large area to get the maximum benefit. Although Sri Lanka's irrigation settlement schemes have traditionally been rice-based systems, the diversified cropping pattern recommended by ADB for the Kirindi Oya Irrigation and Settlement Project (KOISP) is as in Table 10.1.

More recently, consultants to the Irrigation Department have proposed an alternative cropping pattern (Water Management Consultants 1987,16) based on two types of crops: lowland rice, and irrigated (but dry-foot) subsidiary field crops. The Project is in the initial stages of operation and to date (i.e., as of 1989) it has been operated to support rice crops only, to meet the immediate demands of the settlers. In the long run, it should shift to a "water use concept" to support intensification and diversification of agricultural production. The original concept of the project as one intended to support a diversified cropping pattern remains an untested assumption in terms of its practicality and sustainability. However, in this paper, we assume it to be an assumption worth testing.

Project Management Institutions

The Irrigation Department and Irrigation Management Division are the two institutions directly responsible for the operation and maintenance (O&M) of the system. The Irrigation Department is responsible for system O&M to the field-channel level. The water-related activities are directly under the charge of a Chief Resident Engineer. A Senior Irrigation Engineer for water management, working under the Chief Resident Engineer, is responsible for O&M of the new areas of the project, and for the preparation of irrigation schedules, including allocations between the new and old areas. Each of the main canals is assigned to an irrigation engineer for O&M; various technical assistants, work supervisors, and irrigation laborers complete the Irrigation Department staff. Other departments provide supporting services, such as agricultural extension and inputs, land administration, banks, and crop insurance.

At the field-channel level, farmers' groups organized by the Irrigation Management Division are supposed to be responsible for O&M. There are two Project Managers from the Irrigation Management Division, one each for the old and new areas. They are responsible for integrating and coordinating inputs of various departments into the agricultural production process, and for organizing farmers into groups and committees at field-channel, distributary, and project levels to obtain their cooperation. Neither the Project Managers nor the farmers' groups have any administrative or legal authority, and to date, both have been less effective than hoped.

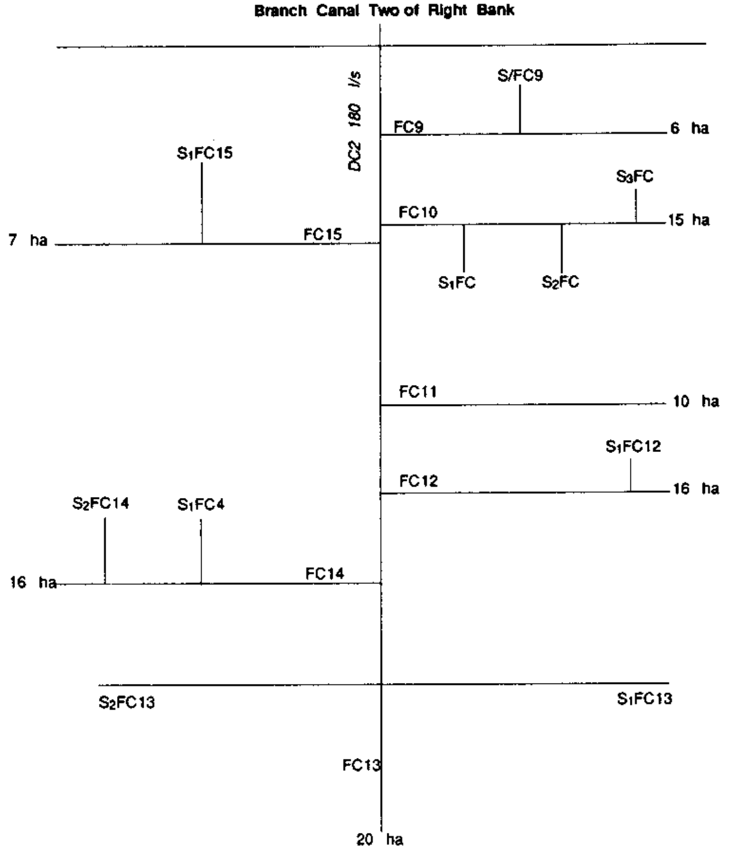
A Project Coordinating Committee, consisting of project and district-level officials and chaired by the Government Agent (GA), has been constituted to take decisions regarding project activities, particularly those related to construction. A subcommittee of the Project Coordinating Committee was formed in mid-August 1988 based on an IIMI recommendation to discuss the agricultural programming for the project in detail. There are also two "Project Committees," for the old and new areas, organized by the Irrigation Management Division Project Managers. These committees include both officials and farmer representatives, and are intended as policymaking bodies for planning and implementation of the agricultural calendar and for system O&M, but to date they have not been very effective. Finally, there is a subcommittee of the District Agricultural Committee, which has some authority in planning cultivation seasons.

The fragmentation and ineffectiveness of the management structure constitute a key factor underlying the unsatisfactory performance of the project.

WATER DELIVERY PERFORMANCE IN ONE SUBSYSTEM

The subsystem selected for this study consists of the distributary channel Number 2 (DC2) of branch canal 2 (BC2) on the right bank main canal (RBMC). It serves a command area of about 91 ha in Tract 5. Each of 91 farmers has an allotment of 1 ha. BC2, from which DC2 takes off, has a command area of 528 ha. While DC2 is the intensive sample study area, BC2 provides the basis for the extensive sample from the next higher-level subsystem (Figure 10.3).

Figure 10.3. Schematic Layout of DC2, Tract 5 of KOISP.



Data collected during the three agricultural seasons starting in February 1988 included hydro-meteorological data, seepage and percolation (S&P) data, discharge data at salient control points, design and operational data, socioeconomic data, and institutional data. However, the analysis presented here is based on the data collected during the yala (dry) 1989 season.

The 1989 yala season commenced with water issues on 15 March 1989, in line with the cultivation meeting decision in which farmers participated. This date was earlier than that recommended by the Irrigation Department, and was adopted at the farmer representatives' insistence. It allowed no time for channel maintenance; and water issues actually commenced before harvesting had been completed in some areas.

As is normal in Sri Lanka, one month was allowed for land preparation. The last date of water issue, originally fixed as 15 July, was later amended to 27 July, but the water issues for rice cultivation actually continued until about 10 August. The total rainfall during the season was about 220 mm, which was very close to the long-term average (250 mm) of the yala season. Most of the evapotranspiration (ET) values during the season were between 6-8 mm, except for a few days when the ET values were low (3 mm), corresponding to times when there were two or more days of continuous rainfall. The measured average value of S&P in the DC2 command area over the season varies from 4.7 mm/day to 10.8 mm/day. However, the S&P values adopted for the preparation of water delivery schedules are 3 mm/day for lowland soils (LHGs), and 6 mm/day for upland soils (RBEs) — i.e., much lower than the measured values.

A typical farmer takes about 4-5 weeks to complete land preparation, from the day he receives water on his allotment until sowing, as against the 3 weeks assumed in preparing the water schedule. The total time required for 100 percent completion of sowing in the study area from the first date of water issue is about 8 weeks as against the 5 weeks assumed in the water delivery schedule. The total quantity of water used by a typical farmer in DC2 for land preparation is about 880 mm/ha comprising about 400 mm/ha for land soaking and about 480 mm for other activities in land preparation, as against totals of 125 and 200 mm assumed for LHG and RBE soils, respectively. The peak daily deliveries of irrigation during the land preparation period are 3.41, 3.58 and 2.68 l/s per hectare at the heads of BC2, DC2 and DC5 canals, respectively. These values are slightly higher than the designed peak land preparation requirements at these levels of the system.

Predictability of Supply

The actual measured deliveries and the target deliveries at the heads of BC2, DC2 and DC5 are shown in Figures 10.4 to 10.6. The supply at the head of BC2 and other sample distributaries fluctuated significantly during the first week of land preparation. This fluctuation is mainly due to the opening and closing of distributaries and field channels taking off from the main canal, manipulations necessitated by the inability of the farmers to receive an early supply of water, and by the preseasonal maintenance

Figure 10.4. Measured deliveries and target deliveries at the head of BC2.

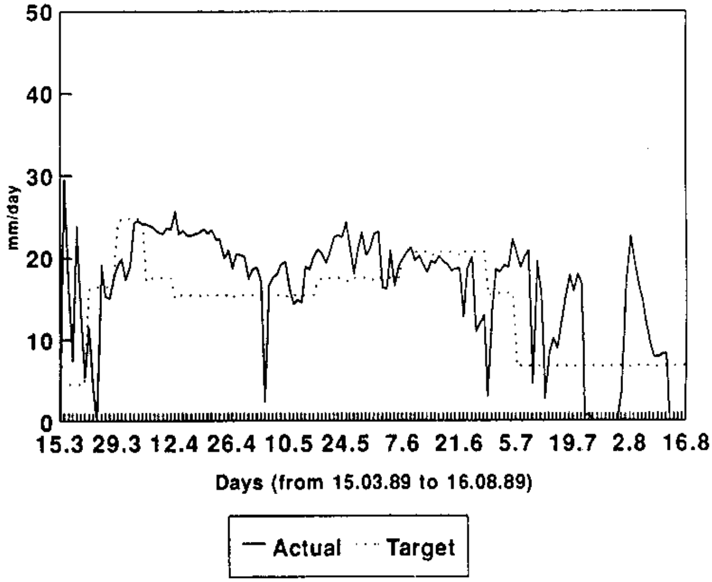


Figure 10.5. Measured deliveries and target deliveries at the head of DC2.

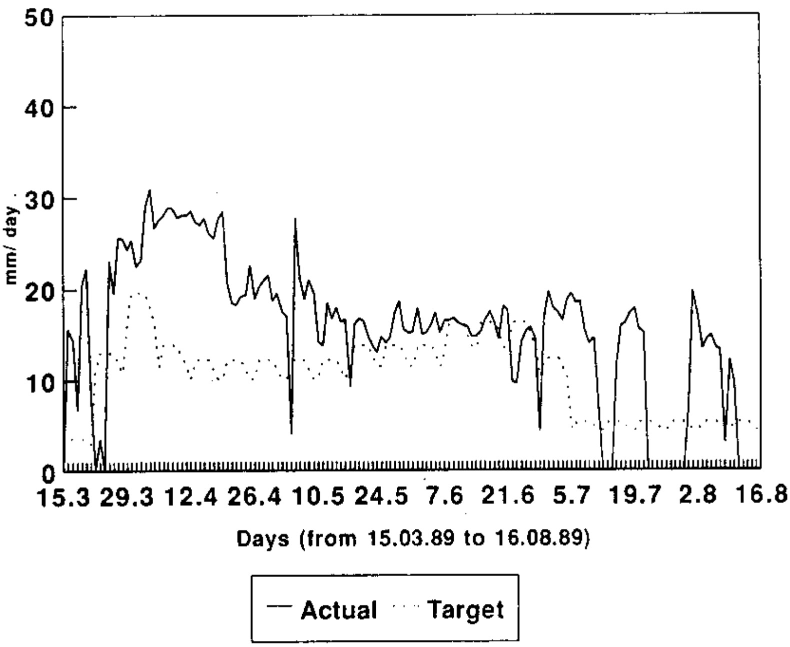


Figure 10.6. Measured deliveries and target deliveries at the head of DC5.

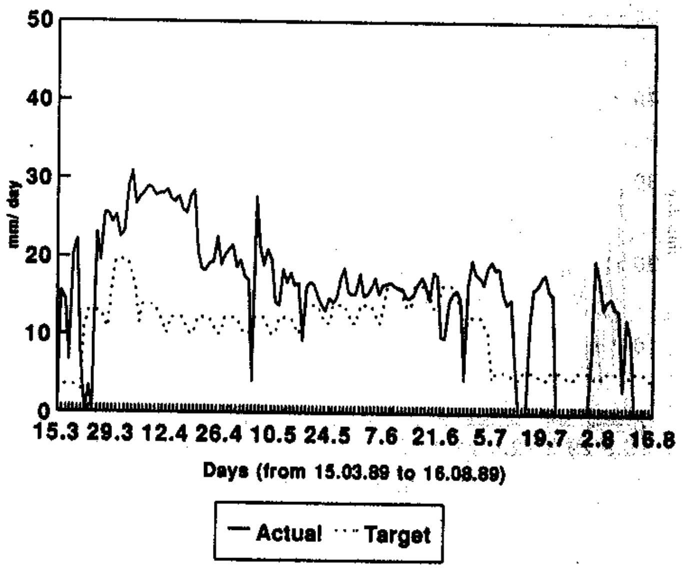


Figure 10.7. Measured discharges versus targets at the head of FC9 of DC2.

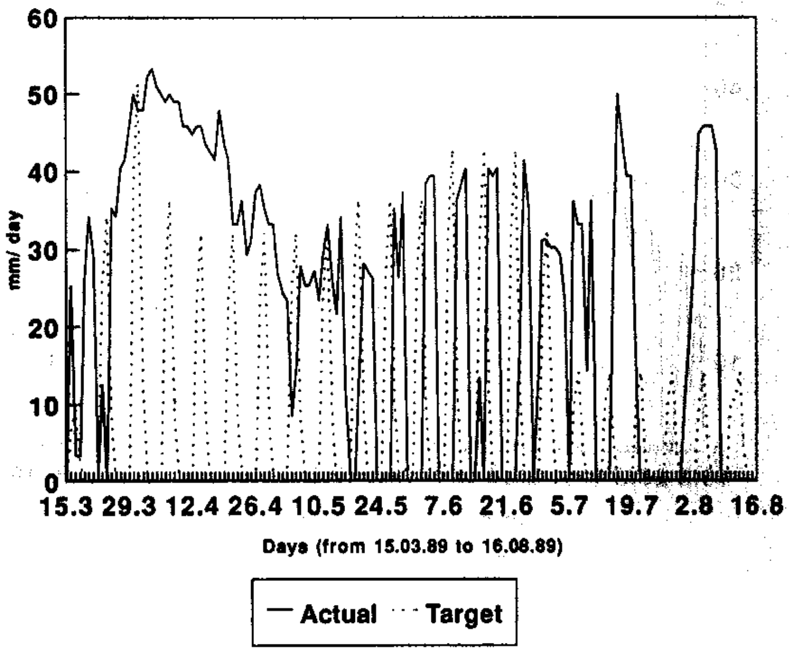


Figure 10.8. Measured discharge versus target at the head of FC10 of DC2.

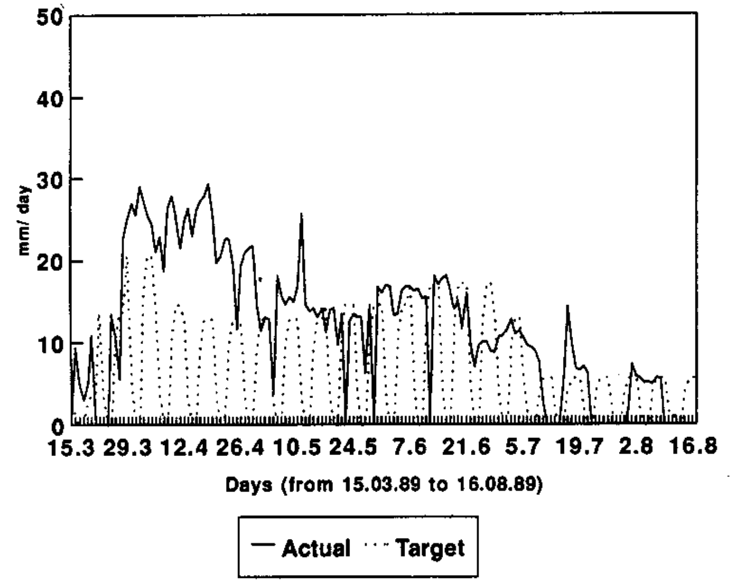
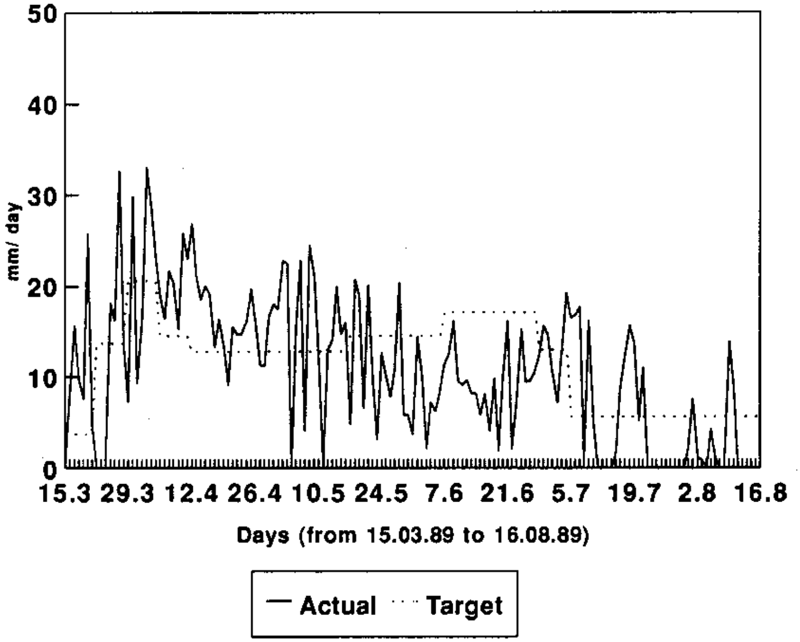


Figure 10.9. Measured discharge versus target at the head of FC13 of DC2.



activities carried out after the release of water for the yala season. It is also seen that from June onwards, the supply was gradually reduced, causing fluctuations at the head of BC2 and other distributaries. This gradual reduction was effected in order to conserve the dwindling storage in the reservoir, while the major fluctuations during this period were caused by the operation of the system to account for the rainfall in the service area. In the subsystem studied, although the supply deviated from the targeted release, the supplied discharges were by and large above the targeted values.

In Figures 10.7-10.9 the measured discharges are plotted against the targets at the heads of FC9, FC10 and FC13 of DC2, representing head, middle, and tail field channels. The figures indicate that the rotation within field channels was introduced only two months after the date of water release, because of the slow rates of land preparation achieved by the farmers. The water supply against the target was predictable except in FC13, the tail-most field channel of DC2, where more than one-third of the allotments (about 7 ha) did not depend on the irrigation supply, as they have access to drainage water for cultivation.

Adequacy of Supply

The adequacy of a given water delivery is a measure of the reliability of supply and, in turn, a measure of the quality of system operation. The adequacy can be evaluated in terms of Relative Water Supply (RWS), which for our analysis is defined as follows (all units in mm):

For land preparation period:

RWS = (IW + Re)/(E + S&P + land soaking and ponded water)

For crop growth period:

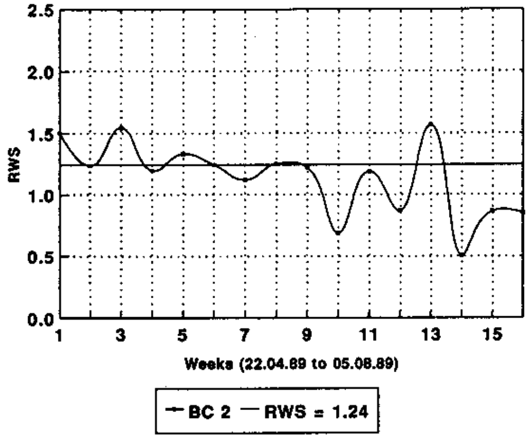
RWS = (IW + Re) / (ET + S&P)

where	IW	=	Irrigation water delivery
	Re	=	Effective rainfall (assumed as total rainfall for yala)
	ET	=	Evapotranspiration
	S&P	=	Seepage and percolation
	E	=	Evaporation

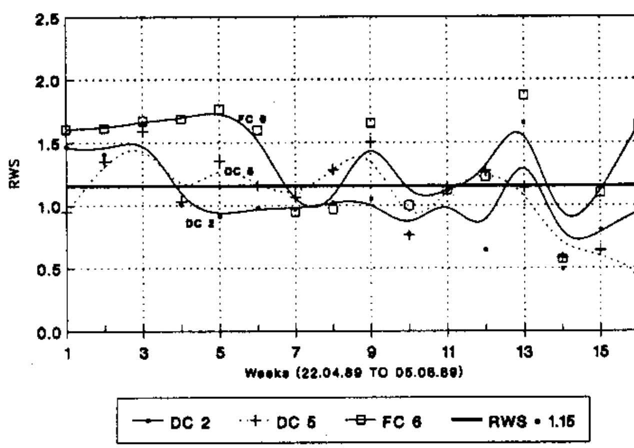
The weekly RWS values at the heads of BC2, FC6 (head), DC2 and DC5 are presented in Figure 10.10, A-D. Similar computations were carried out for the field channels of DC2, and typical curves are presented in the same series of figures. A RWS = 1 at the field means that the supply matches the requirement exactly and is called the "critical RWS" value. If the irrigation water supply is measured anywhere other than in the field, such as a field channel or distributary turnout gate, then the conveyance losses in the channel need to be accounted for in computing RWS values at the field. This would then make the critical RWS values higher than 1. For the purpose of our analysis, the conveyance efficiency in a typical field channel, distributary channel, or branch canal was assumed to be 93 percent, as adopted in the water delivery schedules prepared by the Irrigation Department. This results in "critical RWS" values of 1.07, 1.15 and 1.24

Figure 10.10. The weekly RWS values at the heads of BC2, FC6 (head), DC2, and DC5 and field channels of DC2.

(A)



(B)



(C)

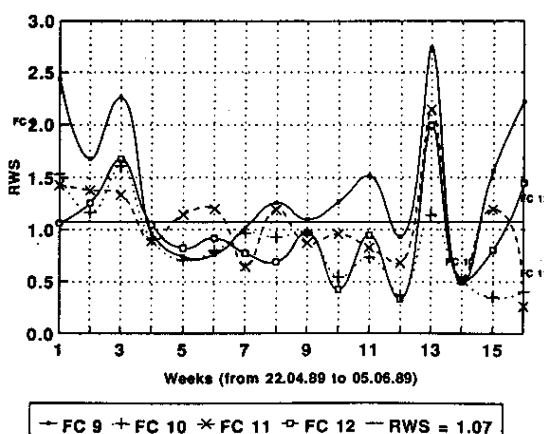
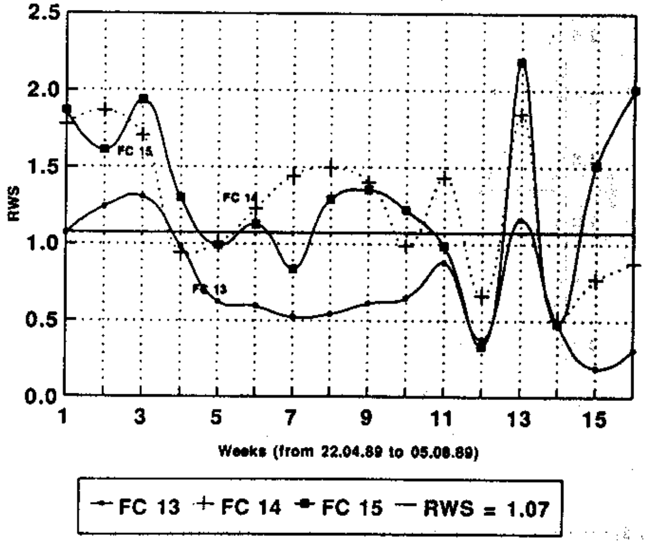


Figure 10.10 (Continued)

(D)



at the head of a typical field channel, distributary channel, and branch canal, respectively.

A comparison of the weekly RWS values in the sample subsystem with the critical RWS values indicates that the actual RWS was above the critical RWS level for most of the time, both along the branch canal and at the heads of distributaries. At the same time, a general trend of gradually declining RWS values over time can be observed, possibly due to the deliberate reduction of supply by the Irrigation Department in view of the gradually declining storage in the reservoir. Similarly, the distribution of computed RWS values at the heads of field channels under DC2 indicates high RWS values throughout the growing season, except for those field channels that receive drainage water (FC10, 12 and 13).

The low values of RWS (0.5 to 0.80) prevailing at the heads of field channels during the latter part of the season imply "undersupply." However, a more sensible comparison of the actual RWS values with the distribution of rainfall over the season, as well as the actual deliveries into the RB main canal and to the other canals in the subsystem, brings out the fact that the Irrigation Department had made a serious effort to economize on water during the rainy periods by either completely withdrawing or reducing the irrigation supply during and after the rains.

Equity of Water Supply

Table 10.2 indicates the mean RWS, maximum and minimum RWS, and the water delivery performance (WDP) parameters as defined by Lenton (1983) assuming equal weights for all periods of the growing season. It is seen that if actual rainfall is taken into account, WDP for all the canals (except FC10, FC12 and FC13) is near or above 1.0, indicating adequate supply. The field channels where WDP is very low benefited from the drainage water in DC2 for part of their command areas.

Table 10.2. Relative water supply (RWS) and water delivery performance (WDP) in yala 1989, RB Tract 5-BC 2 subsystem.

Canal	Maximum RWS	Mean RWS	Minimum RWS	WDP
BC 2	1.57	1 14	0.50	1.12
FC 6	1.87	1.38	0.57	1.36
DC 2	1.65	1.06	0.49	1.08
DC 5	1.59	1.08	0.45	1.08
FC 9	2.74	1.43	0.48	1.36
FC 10	1.62	0.85	0.35	0.81
FC 15	2.19	1.32	0.33	1.27
FC 11	2.15	1.04	0.26	1.00
FC 12	2.00	0.98	0.33	0.94
FC 14	1.87	1.25	0.50	1.23
FC 13	1.31	0.72	0.19	0.74

The distribution of mean RWS values along the branch canal and along DC2 is presented in Figures 10.11 and 10.12. The mean RWS, both in the branch canal and in the sample canals along BC2 is higher than 1.0. Along the branch canal, the supply is not equitable, varying between 1.39 at the head to 1.05 at the middle and tail. Though the head-end (FC6) received more supply, possibly due to its position along the branch canal, the agency has succeeded in maintaining a fairly equitable supply between the middle and tail reaches of the subsystem studied. As far as equity among the field channels within DC2 is concerned, it is observed that the mean RWS of the head end (FC9) and tail end (FC13) are 1.41 and 0.75, respectively. However, contrary to the common perception, mean RWS does not decline gradually from head to tail in proportion to the length of DC2. Some middle and tail field channels attained high mean RWS values (e.g., FC15 = 1.30; FC14 = 1.25) very close to the mean RWS value at the head-end field channel. Only two field channels (FC10 and 13) out of the seven received less than a mean RWS of 1, but both of these benefited from the drainage water from the upper areas.

An inherent weakness of the RWS methodology in assessing the adequacy of supply is that it fails to account for the use of drainage water or for residual water left in the fields due to rain or overirrigation that can be used to supplement the water requirements in the subsequent weeks. The concept of cumulative RWS instead of RWS accounts for the residual water and gives a better representation of available water at the field level. A plot of cumulative RWS as a function of time is shown in Figure 10.13, A-D for BC2, DC2, DC5, FC6 and for field channels along DC2. One can observe

DESIGN, CONSTRUCTION, AND MAINTENANCE CONSTRAINTS ON PERFORMANCE

Design

The design influences the performance of the project in two ways — through the formal set of technical procedures and assumptions adopted for the design of irrigation canals and appurtenant structures, and through the typical operational schedules for the distribution of water.

The size of the turnout area served by any individual field channel is designed on the basis of 8 ha for 100 percent Reddish Brown Earth (RBE) soils and 16 ha for 100 percent Low Humic Gley (LHG) soils. Thus the actual size of any field-channel turnout area is, in principle, determined by the proportion of different soils served by that field channel. However, a random verification of some field-channel turnout areas indicates that the actual proportion of RBE soils has been underestimated in some instances and that turnout areas are larger than expected. This situation can impose capacity constraints on delivery of peak daily irrigation requirements (3.50 l/s per ha for RBE and 1.80 l/s per ha for LHG) with a standard field-channel capacity of 30 l/s.

The design of the irrigation system has underestimated the seepage and percolation rates through the soils. This too can impose capacity constraints in some canals where the exact design section exists without any buffer free-board.

The cross regulators provided along the main canal are intended to insure the driving head required for the release of design discharges to the offtakes located upstream. The trial and error manual procedures adopted for the manipulation of cross regulator gates in order to maintain upstream head and simultaneously to release the required discharge for the downstream command areas cause water-level fluctuations along the main canal.

The designers of the Kirindi Oya irrigation system focused on the management of rice irrigation, since the entire system is actually designed and operated for rice. Little attention has been paid to designing and laying out the system for a mixed cultivation of rice and nonrice crops — even though it was known that the system must support a mixed cropping pattern.

The basic operational design for the water delivery schedules anticipates scheduled rotational irrigation for rice, with the rotation to occur among the field channels and the sharing of water to occur between the farmers. Our research indicated that rotations among the field channels were not implemented systematically and the sharing of water below the field-channel turnouts was taking place in unsystematic and informal ways. This pattern of operation leads to undersupply or oversupply, and eventually to wastage of water.

The preparation of the water delivery schedules for each season begins with information about the intended dates of first irrigation issue and land preparation activities. The period usually allowed for land preparation is one month, but various socioeconomic constraints stretch the land preparation period beyond one month.

Figure 10.11. The distribution of mean RWS values along the branch canal.

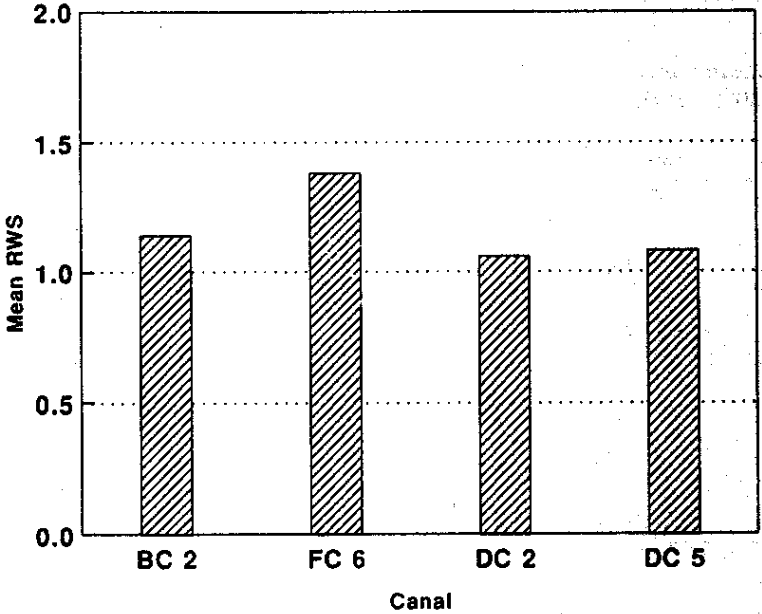
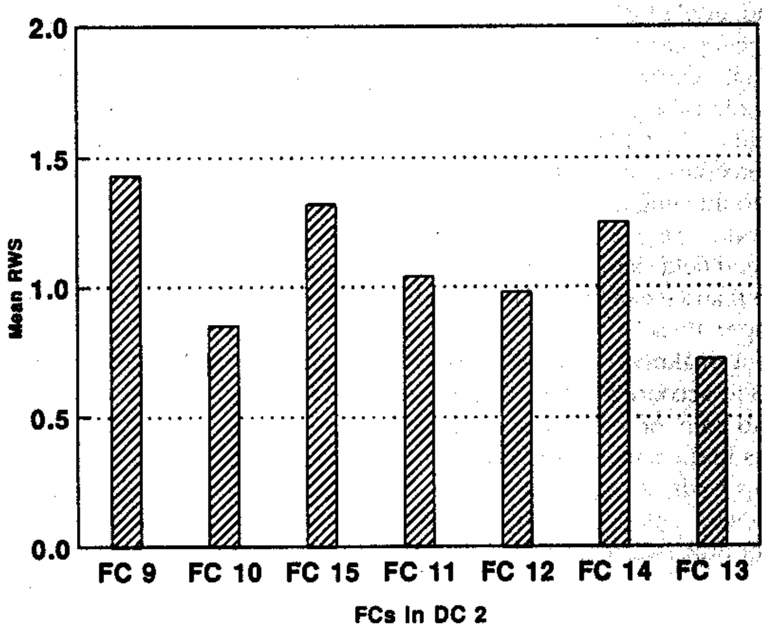


Figure 10.12. The distribution of mean RWS values along DC2.



from these plots that the adequacy of water along BC2 as well as along DC2 is clear and was always equal to or greater than its requirement, except in FC10 and FC13 which have been receiving drainage water.

Although equity among the field channels of the sample subsystem was found to be within acceptable limits, there was a wide variation of water level in the rice fields in different areas, as well as within the same area (maximum 18 cm to minimum –50cm from the bed level).

Figure 10.13. Cumulative RWS as a function of time for BC2, DC2, DC5, and FC6 and for field channels along DC2.

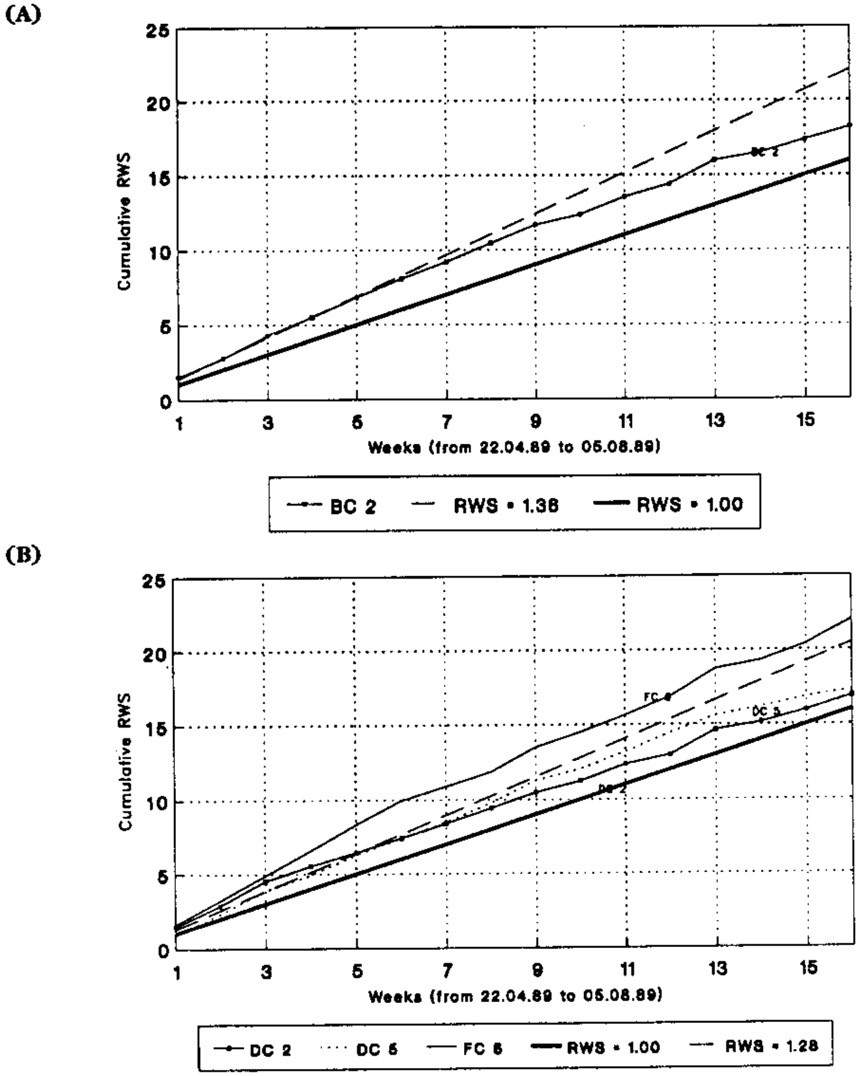
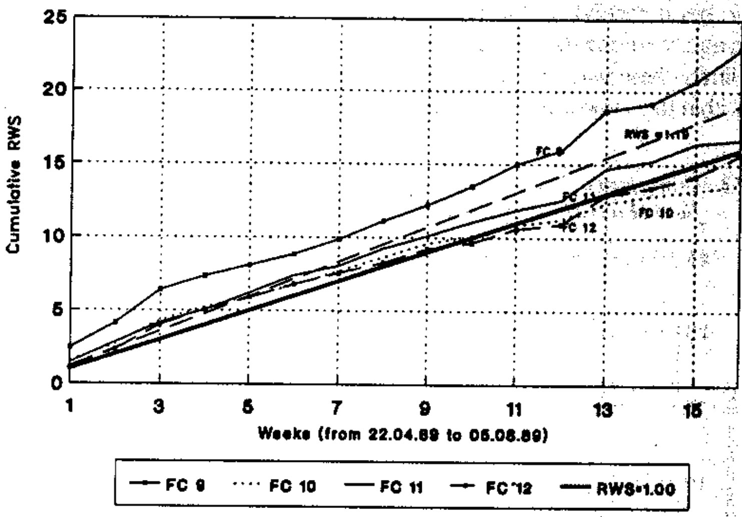
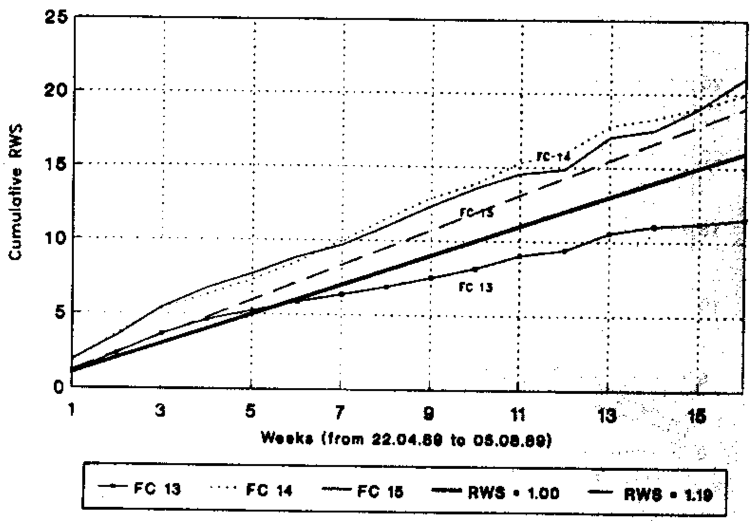


Figure 10.13 (Continued)

(C)



(D)



The wide variation within and between the turnout areas is an indication of ineffective water distribution by the farmers in the field-channel turnout areas. One of the operational assumptions of the design of turnout areas is that the farmers in any given field channel form a cohesive group to share the entire flow in the field channel between two farmers at a time during the rotation interval. While it is true that the Irrigation Department was also unable to adhere to a strict implementation of rotation among field channels, it was also observed that farmers practiced no systematic sharing of the water delivered. In fact, this was the first season in which we observed a pattern of farmer interventions such as manipulating field channel and distributary gates and cutting channel bunds. This, and the high degree of water level fluctuation in rice fields, pinpoint the importance of improved management at the farm level to avoid crop stress.
The following are the important findings of this aspect of the research:

- There exists a considerable difference between the design and operational assumptions and the realities especially during the land preparation phase.

- Although the general pattern of water delivery during the season reflected a trend of fluctuating deliveries at the beginning of the season with a gradual reduction towards the end of the season, the efforts made by the Irrigation Department to match the total supply (irrigation water plus rainfall) to the actual field water requirements made the supply adequate.

- The water used per hectare at branch-canal and distributary-turnout levels during yala was more than adequate, as shown in Table 10.3. This indicates a high potential for water savings in future.

- The water delivery performance during yala 1989 emphasized the necessity of strengthening the communication among farmers, farmer representatives, and agency officials. While there has been considerable improvement in managing the main system during this season by the agency officials (compare IIMI 1988b and 1989a to IIMI 1989b), the management below the turnout needs substantial improvement through effective farmers'organizations.

Table 10.3. Water use at selected turnout gates.

Canal	Position	Land preparation mm	Crop growth mm	Total mm
BC 2	-	723	1,974	2,697
FC 6	Head	885	2,405	3,290
DC 2	Middle	822	1,790	2,612
DC 5	Tail	541	1,662	2,203

The delay in land preparation causes the operation to be carried out in an ad hoc manner during the land preparation period.

The underestimation of seepage and percolation rates and canal conveyance efficiencies in the irrigation schedules can lead to undersupply in some areas (IIMI 1988b).

Construction

The quality of construction also has an impact on water delivery performance in a number of ways.

A set of "as-built" drawings for the irrigation canals should be prepared immediately after construction in order to ascertain the design levels of the canals and other key structures. In Kirindi Oya the as-built drawings are not yet available, and the deviations from the designs during construction are not systematically recorded. This makes it difficult for the operating agency to recognize construction defects, and the true capacities of the canals and control structures. The operation takes place with an implicit assumption that the construction is perfect, which is far from true. For example, our preliminary investigation of BC2 and sample distributaries indicates a mismatch between the design and existing canal-bed levels.

The quality of construction which is a key issue in the long-term performance of the system appears to be average in Kirindi Oya, by Sri Lankan standards. However, work of inferior quality and inadequate foundation work can also be observed. Some canal structures are already undermined or partially collapsed.

The construction of drainage canals received low priority in the construction process. These were done last, and this delay caused the development of salinity and waterlogging in some lower patches of the command of canals. This state of affairs could have been avoided, to a certain extent, if the construction of drainage canals had taken precedence over the construction of irrigation canals, or if the drainage canals had been completed before the first cultivation season.

Maintenance

Once the system is constructed, the quality of the maintenance will determine the long-term capability of the water delivery system to perform at expected levels. Lack of as-built drawings prevents the identification of the actual degree of silting in the canals. This is a major drawback in the overall performance of the system.

The decisions on when to commence the water issue for a season, taken at cultivation meetings, sometimes leave no adequate time for preseasonal maintenance of the system. This leads to operational difficulties and eventually to closing of some canals for desilting after the season has begun. The farmers show very little interest in cleaning and maintaining the field canals. They are not properly organized or motivated to attend to maintenance work.

The main constraint is believed to stem from insufficient funds allocated for maintenance, at least for the routine weeding and desilting of canals before the commencement of a season. The lack of a systematic and well-established procedure for prioritizing and conducting maintenance activities further inhibits performance.

LONG-TERM RESOURCE CONSTRAINTS ON WATER DELIVERY PERFORMANCE

A major objective of the Kirindi Oya project is to make efficient use of scarce water, land, and human and financial resources to maximize farmers' production and income. This is a water-deficit project with very high variability of reservoir inflows. The flow pattern of the Kirindi Oya and its tributaries shows minimum/maximum ratios of 1/6 for annual, and even 1/70 for monthly flow volumes. The long-term average annual inflow into Lunuganwehera Reservoir is estimated at 319 MCM with roughly 114 MCM in the yala season (March-August) and 205 MCM in the maha season (October-February). The old Ellagala system contributes a total of 102 MCM of average annual inflow to its five tanks from its own catchment, giving an overall average availability of 421 MCM in the system. A comparison of recent discharge measurements with the original series of inflow data shows that the recently measured actual inflows are 30 to 40 percent less than originally estimated. Moreover, the reservoir water would be just sufficient to raise one rice crop in the contemplated service area of 12,900 ha. Therefore, use of this water to raise two crops in the area needs very careful water planning, and crops requiring much water, like rice, must be minimized.

The soils within the project service area fall into three main types: reddish brown earths which are moderately coarse and highly permeable, suited for the production of upland crops; low humic gley (LHG) soils which are slightly finer, less permeable, and poorly drained; and alluvial soils rich in clay and finer sediments of fertile river-transported soils. Both LHGs and alluvial soils are suitable for rice cultivation because of their physical properties and physiographic position in the landscape. However, raising rice in the upland area may create waterlogging and salinity in the lowland areas at times of water abundance.

Most of the settlement farmers come from the lower socioeconomic strata of the country, are young with no grownup children to help them in the farming activities, and have to depend heavily upon hired laborers and farm power for agricultural operation. Some settlers have little or no agricultural experience. Hired labor is very costly in the region. This has serious implications for the cultivation of nonrice crops which require more labor. In the study area, 70 percent of the farmers obtained loans from either institutional or informal sources, or both. The interest rate for informal loans is very high (as high as 120 percent per year). Because of the drought and crop failure in the first season (1986/87 maha), about 40 percent of the sample farmers have defaulted on bank loans and are no longer creditworthy. A serious constraint for any innovative development in this project appears to be the poverty of the settlers.

Limited financial resources have had a great impact on the potential performance of the system: cost overruns have led to delays in implementation, and a "least cost" approach is taken in providing all infrastructure and basic services. This underlies some construction quality as well as design problems, inadequate support to settlers to assist them in making the transition to being residential irrigated farmers, and the continuing lack of many basic facilities.

Keeping in mind the insufficient and uneven water supply, increased pressure on the available land for agricultural production, and the need for settling as large a number of farmers as possible at the lowest possible cost, the planners of the project and the water management consultants have recommended a mixed cropping pattern to complement and alternate with rice cultivation. The draft water management strategy plan submitted in May 1987 was worked out for a cropping pattern based essentially on two crops: lowland rice and irrigated subsidiary field crops. These field crops are a mixture of 50 percent 3.5-month-age-group upland crops, and 50 percent 4.5-month-age-group upland crops, both already grown locally to some extent. This cropping pattern would allow irrigation of only the old area plus Phase I of the new area with an acceptable cropping intensity of 175 percent. The intensity, however, drops to an unacceptable 130 percent if the whole Kirindi Oya Project (phases I and II) is included. Because of the low cropping intensity, it was agreed during a joint ADB-Kreditanstalt fur Wiederaufbau review mission in June 1987 that other cropping and water allocation approaches should be investigated. The water management consultants have now recommended a cropping pattern similar to the one given in Table 10.1, based on their simulation studies (Water Management Consultants 1987).

While as of 1989 no decision had yet been taken by the government or the project authorities with regard to the cropping pattern to be implemented, farmers have been cultivating rice throughout the command (upland and lowland soils) in both the maha and yala seasons. Before yala 1989 began, the Irrigation Management Division officials and others attempted to convince farmer leaders to grow other crops, but they were reluctant, for many very good reasons. The Irrigation Department indicated that there was sufficient water to start a rice crop in Tracts 2 and 5 of the right bank, undermining any further effort to change the cropping pattern. The Department did not, however, inform the farmers about the impact of the decision on the possibility of irrigating larger areas, or on the starting date of the following maha. In any case, farmers face various technical, management, and institutional constraints on growing nonrice crops, which are yet to be dealt with by the agencies concerned both at the national and project levels.

Raising rice in both seasons has resulted in a number of problems, both during the yala 1989 and maha 1989/90 (in progress as this paper was written):

- The decision to raise rice during yala 1989 with inadequate storage at the beginning of the season made the Irrigation Department very cautious about water releases from the reservoir, resulting in unreliable water supply especially during the initial stages of land preparation and also during the final stages of crop growth. Since the Department was severely criticized by settlers for its handling of the drought in maha 1986/87, which had led to a total crop failure (see Merrey and Somaratne 1989), its conservatism is understandable. Its objective of conserving the scarce reservoir resource whilst making maximum use of the rainfall and drainage water has resulted in uneven and, at times, inadequate supplies to certain sections of the service area. Better coordination and communication between the farmers, farmer representatives, and agency officials could have improved this situation considerably.

- An even more serious problem for the long-term performance of the system is that raising rice during yala 1989 has left very little water in the reservoir to start the maha 1989/90 in time and to the full extent. The old areas are receiving issues and will have a maha season; and some new area tracts may receive late issues depending on the inflow. This continues a pattern observed since the first season of the project (yala 1986): at any given time, only a few tracts can have a season, but the whole system has never had a simultaneous season. There is a continuous pattern of low intensity land use. This will lead to underdevelopment of the new area, causing social and political dissatisfaction, and could jeopardize the economic viability of the project.

- Once the farmers have become used to growing rice during both the yala and maha seasons it may be difficult to induce them to switch over to other crops at a later date, unless such a change is going to improve the profitability to the farmers substantially. This has been the experience in many Asian countries. By the time the larger system is ready for farmers to shift, they may have neither the inclination nor the resources to do so.

The above arguments and discussion underline the need for two things: a clear and early policy decision with regard to the cropping pattern in different zones of the project area (old system, RB and LB of the new system) and its implementation from the very beginning of the project; and effective infrastructural development for implementing insurance cover for other field crops, bank credit at low interest rates, marketing, and post-harvesting storage facilities for diversification into other field crops.

SOME OTHER ISSUES AFFECTING SYSTEM PERFORMANCE

Priorities in Irrigation Settlement Projects

Although Kirindi Oya is an *irrigation* settlement project, the government gave first priority to settlement. This is due mainly to political pressure — the settlement of beneficiaries was done well in advance of physical construction. Construction of irrigation facilities was given the next priority, but unfortunately, there were significant delays due to improper planning and cost overruns in creating the necessary irrigation infrastructural facilities. This led to a large time gap between settlement and the provision of irrigation services. Having settled the poor farmers and established the necessary infrastructural facilities, the government has not provided the necessary support for irrigation management, including institutional aspects. Coupled with social unrest and droughts, this has had a negative impact on system performance.

Water Allocation Conflicts between Old and New Areas

Many settlement projects in old and new areas have had problems of sharing water among themselves. The old settlers who gain considerable benefit after construction of the project, by way of stabilized irrigated agriculture due to a more reliable water supply and increased intensity of irrigation, nevertheless look upon the new settlers as intruders in their domain of influence. The farmers in the old area generally use more than their allotted share of water, complicating and distorting the allocation of water to different areas.

This can be illustrated with data from the Kirindi Oya project, where the Ellegala old system used to irrigate approximately 130 percent of its service area before the construction of Lunuganwehera Reservoir. In the project proposal, an irrigation intensity of 160 percent with some other field crops for the old system was assumed (without consulting the farmers); but the farmers in the old system now irrigate two rice crops (nearly 200 percent intensity) thereby depriving the newly developed areas of water. The concept of prior riparian right is clearly prevalent in the farmers' minds. This problem must be examined, and a clear policy decision has to be arrived at and enforced; otherwise, one ends up with a system in which a large deficit of water supply occurs in much of the newly developed area.

Another characteristic of reservoir projects in particular is a tendency to switch from the designed cropping pattern to water-loving crops such as rice. This reduces the available water supply to the tail-end region. All these factors suggest the need for better interaction with the public, through such means as a public-hearing system, from an early stage.

Mismatch between Assumed Design and Actual Water Requirement

Many new settlement schemes consume more water than do stabilized irrigation systems, especially when rice is the crop cultivated. Experiences from the Kirindi Oya and Inginimitiya projects indicate that the excess consumption may be as much as 100 percent above the requirements of a stabilized tract (Franks and Harding 1987). There are many reasons for this. First, the virgin soil, when it is irrigated with ponded water for rice cultivation, has high S&P values. In such soils, no clay pan has formed. The horizontal seepage through field bunds is also very high.

Second, settlers do not have adequate resources in terms of equipment (tractors, bullocks, laborers, etc.) and funds to enable them to adhere to strict water scheduling, especially during the land preparation period. For example, farmers in the Kirindi Oya project took two months during the yala 1989 to complete the land preparation as against one month of stipulated time, and used roughly 880 mm of water per hectare, which by any standard is very high. Therefore, in new settlement projects, excess use of water is bound to occur during the initial stages of project development and this aspect needs to be considered while water budgeting for the project.

Behavioral Pattern of Settlement Farmers

The settlement farmers are a group of people coming from different walks of life with diverse social habits and cultural patterns. Many have had no experience in irrigated agriculture; in interviews a few have even stated they have no wish to be farmers. Though, by law, the settlers should not possess any other land or business to be eligible for receiving land, some of them own land or are engaged in business in their original villages. They generally commute between the settlement hamlet and their own village where their families and relatives live. The frequent absence of many farmers from the settlement hamlets hampers efforts to organize farmers for irrigation management. In the Kirindi Oya project, about 30 percent of the farmers have apparently already leased out their allotments. Only the poorest of the poor stay in the settlement hamlets, and they posses neither the incentives nor the resources to carry out efficient farming operations.

Many settlers were brought to the project area long before the supply of water, in the hope that these farmers would work on their allotments and prepare them for irrigation, but many have had to wait up to three years for the first water supply. During this intervening period, they have had to depend on a government food subsidy. Many of them had spent whatever savings they had brought with them. Therefore, at the time of starting the irrigation, they had to borrow money either through banks or from private sources. Under these conditions, even if there is one crop failure (as in fact there was), many farmers cannot overcome the crop loss and consequent financial losses.

CONCLUSION

We are at too early a stage in our analysis and thinking to come to firm conclusions, but a few observations can be made. Franks (1989) and Franks and Harding (1987) have focused attention on the special nature of the problems in "commissioning" new irrigation systems, based on work in another new irrigation settlement scheme in Sri Lanka. They note that in the initial stages there is a tendency to use water far in excess of design assumptions. If this is catered to, it often leads to head enders becoming accustomed to receiving water in excess of crop requirements, a difficult habit to change later. System managers are not sensitized to the special nature of the commissioning period, and are not trained to take special precautions. Franks and Harding (1987) suggest, for example, that in the first seasons only 50 percent of each rice allotment should receive water. Franks (1989) also refers to Stanbury's (1989) work in Kirindi Oya on the lack of "commissioning" to enable settlers' institutions to develop and work effectively.

Kirindi Oya presents a special problem not faced in most other Sri Lankan irrigation settlement schemes. Kirindi Oya is a comparatively severely water-short system, which has been justified economically from the beginning on the assumption that farmers would grow a lot of nonrice crops. In the Appraisal Report (ADB 1986), a 200 percent cropping intensity is stated as the objective, with a mixture of rice and nonrice crops as given in Table 10.1. More recently, the water management consultants have proposed as the "most feasible" scenario one that mixes rice and other crops on lowland areas, and irrigated and rain-fed crops on upland areas (Water Management Consultants 1987: Volume 1). This is based on computer simulation modeling of the likely water availability in the project area.

With hindsight, as noted above, it can be seen that serious errors were made in the planning and design stage. Although mixed cropping was a stated objective, the designers assumed that the normal design parameters used for rice-based systems could also cater to the demands of nonrice crops. While this assumption is not invalid, the present design permits rice cultivation on well-drained soils in a system whose total water supply is inadequate to support this crop. No operational plan was developed, let alone validated, at the design stage for the support of nonrice crops. The situation is compounded by the serious underestimation of total water availability. The rice-based design and operations to date are totally inappropriate, given the water and soil conditions in Kirindi Oya. Since a complete redesign and reconstruction of the system are not feasible now or in the near future, the government must focus on institutional and management inputs that we believe could improve the performance significantly, even given the present design.

To date, the Kirindi Oya system continues to be operated as a rice-based system, in which only small patches of nonrice crops are grown with special assistance from the Department of Agriculture. We suggest there are two reasons for this pattern. First, there is a continuing "rice bias" or "rice-based thinking" underlying the management of the system. Farmers and officials share a fundamental and deep-rooted bias towards rice. There are strong cultural reasons for this, but this bias probably has so far prevented farmers and managers from seeing alternative scenarios (such as the one proposed by the water management consultants) as practical, or at least worth a serious test.

A far more significant factor lies in the project management structure. The water management consultants were consultants to the Irrigation Department. But this Department does not have responsibility for achieving the overall project objectives, or for implementing a long-term agricultural production plan. Its job is to deliver water, within the constraints imposed by water availability, finances, the physical condition of the system, etc. It responds to farmers' demands to the extent possible, but since both farmers and the Department are accustomed to dealing with irrigated rice crops, that is what they do. Other agencies have their own specified technical functions, but no agency is responsible for achieving the long-term objectives of the project.

There is therefore a de facto policy of catering to short-term objectives, i.e., providing water for rice in a few tracts, on an ad hoc tract-by-tract rotating basis, depending on the water in the reservoir at any given time, but with the old area always getting sufficient water for growing rice two seasons per year. This satisfies farmers' short-term interests, as they wish to grow rice, and it is easy since the agencies, whether the Irrigation Department or the Department of Agriculture or others, know how to support rice production. New area farmers have not yet organized against the old area farmers, but the latter are organized to demand priority. Further, the various farmers' objectives may be quite at variance with the objectives of the management agencies.

The result is that the system management is unable to get the system as a whole onto a seasonal rotation, i.e., maha-yala-maha. As the reservoir was emptied to support yala 1989, only the old areas and perhaps one or two new area tracts will have a maha crop — a late maha rice crop — in 1989/90. The same pattern is repeated in yala, with some tracts even straddling the seasons (late maha or early yala) and growing rice. The precedence of short-term objectives prevents the achievement of longer-term objectives, and reduces the likelihood of achieving them as people get used to a certain pattern.

The research conducted in the BC2 subsystem indicates the potential for improving the water delivery performance with the active involvement of the system managers, including farmers, in actual operations. Recent signs of improvement (see IIMI 1989b and 1990) stemmed from organizational changes within the Irrigation Department. This may be a starting point for further improvement. However, interagency cooperation must be strengthened and a system for reconciling the objectives of various groups of farmers and agencies is required if the long-term objectives of the project are to be achieved.[58]

Since a major cause of the problem is institutional and managerial, the solution would also appear to lie in this realm. It is necessary to establish an overall project management system, which has the long-term objective of making the best use of the limited water to maximize farmers' incomes, and which has the authority to insure that other departments contribute their efforts to achieving this objective. Performance of the overall management would be assessed on the basis of its achievement of the longer-term objectives; assessment of the performance of other departments would be based on their contributions to their achievement. Institutions to facilitate consultation with, and the involvement of, legitimate farmer representatives would be a requirement, as would political support from above.

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[58] Since mid-1989 the government has taken important steps that at least begin to address these issues; the management changes initiated after an early draft of IIMI's final report are documented in the final report (IIMI 1990), and future reports will document the impact of these innovations.

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