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Research Report

Water Distribution Rules and Water Distribution Performance: A Case Study in the Tambraparani Irrigation System

Jeffrey D. Brewer, R. Sakthivadivel, and K.V. Raju

International Irrigation Management Institute

Research Reports

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Glossary

Advance kar season	April-July
Anicut	Diversion weir
Cusec	Cubic feet per second
Kar season	June-September
Laskars	Gate operators
Pishanam season	October-March
PWD	(Tamil Nadu) Public Works Department
TNEB	Tamil Nadu Electricity Board
WUA	Water users association

Summary

This report makes two arguments about the relationship of water distribution rules to water distribution performance. First, it argues that if the water distribution rules define a pattern of water delivery that does not match technically feasible goals of the water users, then the users will subvert the rules. This will lead to poor water delivery performance and increases in the cost of irrigation to the users. Second, it argues that inconsistency in the water distribution rules creates difficulties in system operations that are likely to lead to inefficient and inequitable water distribution performance.

Data from the Tambraparani Irrigation System in Tamil Nadu, India, are used to demonstrate these points. Specifically, the allocation rules do not provide for the irrigation of bananas although farmers want to plant them. Farmers take a variety of actions to get water for their bananas. In addition, inconsistencies in the Tambraparani rules make it difficult to operate the system according to the rules. For example, the rules for the operation of the system reservoirs limit flows to less-than-required for irrigation during some periods. The various inconsistencies lead to unpredictable water deliveries. The resulting inefficiencies and inequities are demonstrated using data for the year 1994–95.

It is argued that the problems at Tambraparani arise from fundamental issues that apply to all large irrigation schemes. In particular, increasing demands on irrigation systems from both farmers and other users make it essential to modify water distribution rules over time. Resolution of these problems requires devising a system by which responsible persons review system performance and can initiate changes to water distribution rules as needed. It is further argued that involvement of the users in these changes is essential to ensure that the distribution rules serve their desires and that the users accept the limitations on uses imposed by water availability and the features of the system.

Water Distribution Rules and Water Distribution Performance: A Case Study in the Tambraparani Irrigation System

Jeffrey D. Brewer, R. Sakthivadivel, and K. V. Raju

In this report, we explore the relationship of water distribution rules to water distribution performance. Specifically, we make two arguments:

- If the water distribution rules of an irrigation system define a pattern of water delivery that does not match technically feasible irrigation services desired by the users, then the users, often in cooperation with system managers, will modify or subvert the rules to bring water delivery into accord with their desires. Subversion of the water distribution rules will adversely affect water delivery performance, especially equity of distribution, and will raise the cost of irrigation to the users.
- Inconsistencies in the water distribution rules create difficulties in system operations that lead to inefficient and inequitable water distribution performance.

We use data from the Tambraparani Irrigation System in Tamil Nadu, India, to demonstrate these points. In addition, we argue for the relevance of these propositions to many other irrigation systems. We show that farmers and system managers in the Tambraparani Irrigation System in South India systematically subvert water distribution rules that interfere with delivering water as desired by the farmers. We then show that this subversion leads to loss of control by the system managers, to inequitable and unpredictable deliveries, and to raising the transaction costs of getting water. We also show that the Tambraparani water distribution rules are inconsistent and that these inconsistencies lead to interference with operation of the system.

Relation of Water Distribution Rules to Water Distribution Performance

This section discusses the conceptual foundation for the two arguments on the relation of water distribution rules to water distribution performance and briefly reviews the existing literature.

Water distribution rules

Importance. Distribution of water to users within an irrigation system involves such decisions, as who is to get water, how much is to be delivered to each user, at what time will it be delivered. These decisions are usually made with the help of publicly recognized water distribution rules (Coward 1980). One reason for the existence of water distribution rules is to simplify decision making. Irrigation management decisions and tasks are repeated at least once a year. Water distribution rules reduce the effort needed to make these decisions. Rules codify past experience, allowing a new decision maker to benefit from the past learning. If multiple decision makers are involved, rules simplify coordination of decisions.

A second reason is to reduce potential for conflicts. When there are multiple potential users of the irrigation water, all may want access to the water. Water distribution decisions are political acts that involve balancing the interests of each potential user against the interests of all the others. Publicly recognized water distribution rules give decision makers and potential users a basis for agreement, reducing the potential for conflicts (Bottrall 1981; Sampath and Young 1990).

Like many other irrigation specialists, we feel that characteristics of water distribution rules have important effects on irrigation management performance.

Definition. As used here, water distribution rules are a class of "rules" as defined in the literature on common property management (Ostrom, Gardner, and Walker 1993). In this view, water distribution rules make up one type of irrigation management institution. Our concept of water distribution rules is inclusive and subsumes such concepts as "water allocation rules," "water rights," and "system operating rules."

We define water distribution rules as statements that define how water is to be distributed to the users. To qualify as a water distribution rule, a statement must specify at least one of the following:

- the persons or groups of people to whom water is to be delivered (the *users*)
- the amount of water to be delivered to each user (*water quantity* or *discharge*)
- when water is to be delivered to each user (*delivery period*)
- the person(s) or group(s) empowered to make decisions about water deliveries (the *system managers*)

The set of water distribution rules for any irrigation system must, directly or indirectly, define all four of these items. These items can be defined directly in a number of ways.

Users can be individuals, groups of persons, or formal organizations. They can be defined by specific name (e.g., A. B. Rao), by common attribute (e.g., banana growers), or by water outlet (e.g., farmers taking water from the Nadhiyunni Channel). While a statement may use any of the three ways to define users, an outlet must be specified for actual water delivery.

The amount of water may be specified as a quantity or as a discharge rate. *Water quantity* may be defined by volume of water (e.g., 5 million m^3), as "enough water" for a particular purpose (e.g., water for 2 ha of rice), or by a rule that specifies how the quantity is to be determined (e.g., as much as the user pays for). *Discharge* (water flow) may be specified by discharge measurement (e.g., 4 m^3/s) or by fraction of water flow (e.g., 30% of the river discharge).

Delivery period can be defined by definite dates (e.g., from 4 January 1996 to 23 January 1996), by times within the hydrologic cycle (e.g., in June of each year), by an indefinite period (e.g., "from the date of this order"), by sequential turn (e.g., following M. Gandhi), or by a rule that specifies how the period will be determined (e.g., 24 hours after the order is placed).

System managers must be identified by specific name or by title within a named organization.

Water distribution rules may also specify any of the first three parameters (users, quantity, and period) indirectly. That is, the rules may identify a system manager who is empowered to decide on any or all of these parameters. The rules may also specify procedures or principles to be followed when making the decision. For example, many allocation rules specify that an irrigation officer must determine the water availability for a season and then must allocate the available water to users according to rules that give priority to some users over others.

In addition, a water distribution rule may specify the purpose for which the water is to be used. The purpose may define a condition under which water will not be delivered even if the allocation has been made. For instance, if water is allocated to a farmer to grow sorghum but he plants rice instead, the system managers may be authorized to refuse delivery of water to that farmer.

Characteristics. Water distribution rules are statements in ordinary language. They are subject to the problems and advantages of ordinary language; they may be more or less vague, more or less inclusive, etc. One consequence is that the water distribution rules can never cover all possible situations: they necessarily abstract from reality to be codified into language.

Water distribution rules for an irrigation system form nested sets. There are generally multiple water distribution rules for an irrigation system. Some define key parameters for the whole system during a whole crop season. Others define the parameters for part of the season (e.g., during the land preparation period) or for part of the system (e.g., for the main system only). The highest-level rules are *allocation rules* that assign water to users. Lower-level rules are *scheduling* or *operation rules* that define how water is to be delivered according to the allocations. Different rules in these sets of rules may originate from different sources, including law, agency regulations (Radosevich 1986), and custom.

To be effective, water distribution rules must be accepted as valid by most of the interested persons, including those who have the power to flout the rules for their own benefit. In modern societies, getting such acceptance usually means that at least some of the rules must be codified into written documents such as laws and regulations. However, not all distribution rules need to be formally codified; there may be publicly accepted rules that are passed on via word of mouth, even in the largest systems (Ostrom, Gardner, and Walker 1993).

Formal rules. Because there may be differences of opinion among users or system managers about the validity of rules, in this report we restrict consideration to "formal" water distribution rules. Formal rules are defined as those that have been formally adopted by a recognized sanctioning authority, such as a national or local government. Formal rules are codified, usually written down in a recognized document, and have enforcement mechanisms specified; that is, if the rule is broken an appropriate person can take actions to punish the rule breaker or to change his actions.

When formal water distribution rules are inappropriate, people may respond by creating new and informal versions of the rules. We will not treat such informal versions as water distribution rules. It is possible that, over time, informal rules will become widely accepted and formalized.

Interactions of water distribution rules. To understand the relations of the distribution rules to water distribution performance, we believe that it is important to identify all the water distribution rules that apply to the irrigation system. This is because rules interact. For example, in the Tambraparani Irrigation System, the rules for hydropower generation strongly affect how system managers follow the main system management rules. When only one rule is studied in isolation, it is quite likely that the implications of the interactions will be missed.

Studies linking rules and performance

In the scholarly literature, there has been considerable discussion about the relationship between water distribution rules and water distribution performance. These discussions fall into four groups of studies.

A number of studies have used simulation models to investigate which of several distribution rules is best for some class of irrigation systems (e.g., Anderson and Maass 1987; Chaudhry and Young 1990; Howe 1990; Kelley and Johnson 1990). These studies necessarily simplify both the rules and the situations in which they are used so that the full consequences of a given set of rules cannot be determined.

A second group comprises studies of the distribution performance of irrigation systems that refer to the consequences of water distribution rules. For example, Malhotra's (1982) study of the *warabandi*[1] management system in Haryana describes the water distribution rules and concludes that they contribute to good performance. In contrast, Palanisami (1984) finds that the performance of the Lower Bhavani System in Tamil Nadu is not good and that some of the problems are caused by a rule for rotating water supplies among different groups of farmers. These studies do not attempt to separate the consequences of the rules from the consequences of other aspects of system management, such as the physical structures, information systems, and other facilities for management.

The third group of studies focuses on how or whether distribution rules are followed. For example, Bandaragoda and Rehman (1995) show that warabandi rules are not being followed in parts of Pakistan and conclude that the reason is poor main system performance (cf. Lowdermilk 1990). Similarly, Wade (1987) shows that many farmer actions against the rules result from the failure of the main system to deliver water as it should. Vermillion (1986, 1991) explains how and why farmers regularly deviate from the rules. He argues that such deviation is an effective adjustment of inflexible rules to varying local situations. The studies in this group throw light on the links between the rules and farmer behavior, but they generally do not address the consequences of this behavior for distribution performance; Vermillion's studies are an exception.

Finally, a recent group of studies approaches irrigation management as a case of management of common pool resources (Ostrom 1992; Ostrom, Gardner, and Walker 1993). These studies focus on explaining the behavior of farmers and system managers, but some may discuss system performance. For example, Tang (1992, 1993) compares performance evaluations and generalized distribution rules in 47 irrigation systems. Tang does not draw firm conclusions, but his evidence suggests, among other things, that a rule allocating water to farmers in strict proportion to landholdings leads to poorer performance than allocation to farmers through multiple criteria. Tang's study, however, does not explain how differences in rules lead to differences in performance.

The first two groups of studies explicitly or implicitly focus on the question:

[1]The narrow definition of warabandi is a rotational method for distribution of the available water in a part of an irrigation system by turns fixed according to a predetermined schedule specifying the day, time, and duration of supply to each irrigator in proportion to the size of his landholding in the outlet command (Bandaragoda and Rehman 1995). However, the term is used here in the wider sense of the whole distribution system found in Northwest India and Pakistan.

what is the best set of distribution rules for specific situations? The latter two groups focus on why a set of rules works or does not work. While all these studies are relevant, none attempts to generalize about how water distribution rules are related to water distribution performance.

Perry (1995) offers a broad and persuasive hypothesis about the relation of water distribution rules and system performance. He argues that, if the physical infrastructure and the management personnel are not capable of delivering water as specified by the water distribution rules, the result will be poor system performance. Following Perry's lead, we suggest that a general study of the relation between water distribution rules and water distribution performance should focus not only on the internal characteristics of the rules, but also on the factors to which the rules must be adapted to result in good water distribution performance.

Deficiencies in water distribution rules

Mismatch between rules and farmers' desires. Farmers' desires for irrigation services are based on the crops that they want to grow within the recognized limits of water availability in the irrigation system. Water distribution rules limit the quantity to be supplied or the period of supply. Farmers' crop choices are restricted to those crops that can be grown with the water quantity or schedule defined by the rules. If farmers perceive an opportunity to grow a more profitable crop outside the choices permitted by the water distribution rules but within the technical possibilities of the irrigation system, they can (a) submit to the limitations imposed by the distribution rules, (b) evade or subvert the rules, or (c) attempt to change the rules.

If farmers submit to the rules, they resign themselves to lower returns from irrigated agriculture than they believe they could get otherwise. This outcome is unlikely unless they perceive little difference in the returns or see no opportunity to evade or modify the water distribution rules.

Evasion or subversion of the rules is likely, but both raise transaction costs. First, evasion or subversion generally requires the cooperation of the system managers; giving gifts or making payments is a common way to get managers' cooperation. Not only does this raise the cost of irrigation, it also may force users to invest in actions to protect their "rights." Second, if the rules are evaded or subverted, some users feel that their water is going to others, resulting in conflicts between farmers or between farmers and the system managers.

Changing the rules would be the best solution. However, the procedure for changing the rules may be difficult. Also, attempts to change the rules may lead to conflicts among users with different interests and between users and system managers (e.g., Brewer 1996). Users may prefer to evade or subvert the rules if they feel that such actions have lower transaction costs than changing the rules.

Farmers' desires and the limitations of the irrigation system. The overall water availability and the technical features of an irrigation system limit the possibilities of water distribution. There is a need to ensure that farmers understand the limits so that they do not demand more than the system can feasibly provide. Conflicts among farmers and between farmers and system managers may be exacerbated by farmers' failure to understand the limitations of the irrigation system. We return to this point in the last section of the report.

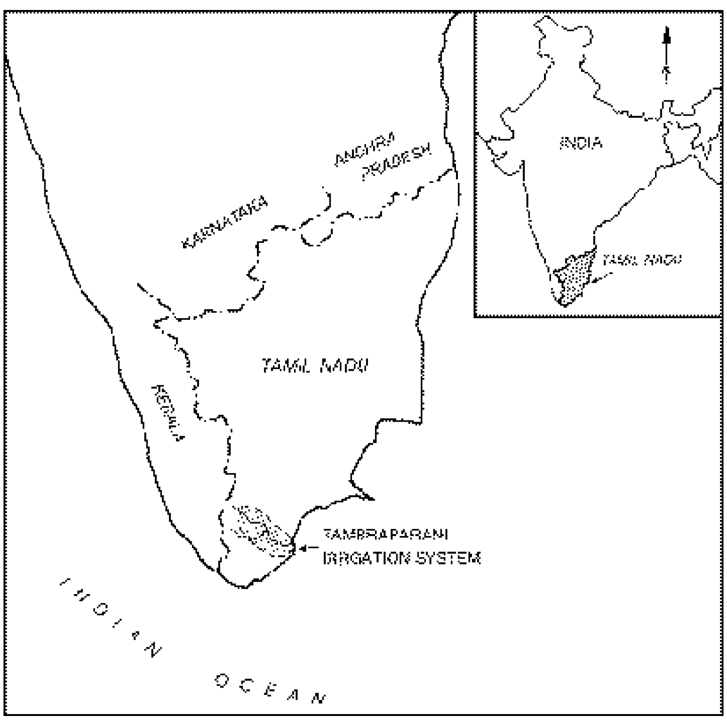
Inconsistency in the rules. Inconsistency in the water distribution rules means that following one rule makes it difficult or impossible to follow one or more other rules. Such inconsistencies are problems for the system managers; they are generally forced to choose which rule to follow in each circumstance. System managers' actions are supposed to be guided by the rules. If they cannot follow all the rules, this provides an opening for criticism of their performance and for others to influence their actions. Inconsistencies may also be problems for the water users if the inconsistencies prevent effective system operation.

Features of the Tambraparani Irrigation System

Location

The Tambraparani Irrigation System lies in the Tambraparani basin at the southern tip of India (fig. 1). The Tambraparani River originates in the Western Ghat mountains and flows southeastward 120 kilometers to the Gulf of Mannar. Some of the bigger tributaries of the river are Servalar, Manimuthar, Gadana, Pachaiyar, and Chittar. The total registered command of the Tambraparani Irrigation System is 34,934 hectares.

FIGURE 1.
Location of Tambraparani Irrigation System.



Historical development

Irrigation development in the Tambraparani basin dates back several centuries. The present system has grown by amalgamation of previously independent parts.

Over several centuries, villagers in various parts of the present command constructed tanks (small reservoirs) for irrigation. Prior to the British period, seven anicuts (diversion weirs) were built in the Tambraparani River. Nine channels were constructed to lead the water from these anicuts to existing local tanks. Some channels also irrigated land directly. An eighth anicut and two additional channels were completed in 1868 during British times.

In the 1940s, the government constructed the Papanasam Reservoir for flood control and hydroelectric power generation. The reservoir is near the headwaters of the river, but the Papanasam powerhouse is located some distance downstream.

In 1958, the Tamil Nadu Public Works Department constructed a reservoir on the Manimuthar River, a tributary of the

Tambraparani, to stabilize irrigation under the Tambraparani Irrigation System and to provide water to 349 tanks outside the system.

In 1986, the Tamil Nadu Electricity Board completed a reservoir on the Servalar River, another tributary of the Tambraparani, and linked it to the Papanasam Reservoir with a tunnel. A powerhouse was constructed at the foot of the Servalar dam.

Over the centuries, formerly independent tank and "run-of-the-river" diversion systems in Tambraparani have been transformed into a single mixed irrigation system. Most of the water in the basin is now captured in the three reservoirs or in reservoirs on other tributaries of the Tambraparani. The riverbed now serves as the main channel of the system. From the river, water is diverted by the 8 anicuts into 11 channels. Farmers irrigate directly from the channels and indirectly from 187 tanks fed by the channels. Figure 2 shows the main features of the Tambraparani Irrigation System; these features are described in table 1.

Water resources

The Tambraparani catchment area receives more than 4,000 millimeters of rainfall annually, making the Tambraparani a perennial river. Rains occur during both the southwest monsoon (June-September) and the northeast monsoon (October-December). Rains in the command area fall during both monsoons but are much lighter than in the catchment. About 60 percent of the command's 752-millimeter mean annual rainfall occurs during the northeast monsoon.

The channels of the Tambraparani Irrigation System are located on contours on both sides of the river; the area between the channel and the river forms the command. Drainage water flows back into the river or into a lower channel. About 13 percent of discharge into the channels comes from return flows.

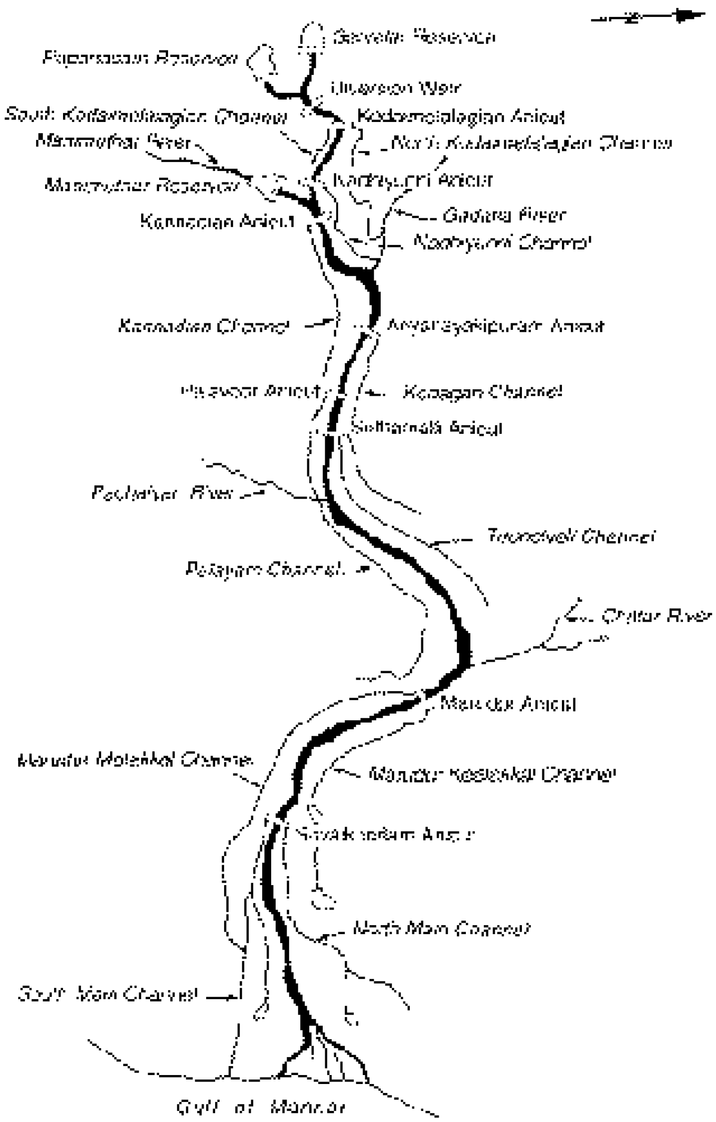
Groundwater is used for supplemental irrigation when surface supplies are not sufficient, particularly during April, May, and

TABLE 1
Components of the Tambraparani Irrigation System.

Anicut	Channel	Channel length (km)	Tanks (no.)	Command area (ha) Direct	Indirect[a]	Total
Kodaimelalagian	South Kodaimelalagian	8.64	-	357	-	357
	North Kodaimelalagian	18.51	20	532	393	925
Nadhiyunni	Nadhiyunni	11.55	-	1,053	-	1,053
Kannadian	Kannadian	33.95	16	4,182	876	5,058
Ariyanayakipuram	Kodagan	29.04	17	1,295	1,133	2,428
Palavoor	Palayam	42.46	59	1,862	1,983	3,845
Suthamalli	Tirunelveli	29.14	23	1,022	1,572	2,594
Marudur	Marudur Melakkal	19.84	16	1,843	3,330	5,173
	Marudur Keelakkal	17.92	15	1,202	1,952	3,154
Srivaikundam	South Main	33.87	15	1,090	4,076	5,166
	North Main	36.32	6	1,331	3,850	5,181
Total			187	15,769	19,165	34,934

[a]From tanks fed by channels.

FIGURE 2.
Features of the Tambraparani Irrigation System.



Source: Pundarikanthan et al. 1992.

June. Groundwater use is increasing slowly, particularly in the tail reach of the system. Relatively high costs of well installation and electrical connections have slowed the development of groundwater. In addition, officials and farmers are concerned about seawater intrusion and both groups are reluctant to make extensive use of groundwater.

Changing water uses

Since the completion of the Papanasam Reservoir in the 1940s, major changes have occurred in uses of water in the Tambraparani Irrigation System.

Power generation. Water from Papanasam and Servalar reservoirs is now used for electrical power generation throughout the year.

A new crop season. Traditionally, rice was grown in the whole Tambraparani command during *pishanam* (October-March) and *kar* (June-September) seasons. The system was closed for repairs during the rainless months of April and May, although releases were made for nonagricultural purposes. In the late 1950s, farmers near the tail of the system began to agitate for permission to plant crops during these months. In 1969, the *advance kar* season, running from April through July, was created. Today, in the head and middle reaches of the system, rice is cultivated during pishanam and kar seasons. In the tail areas, rice is grown during pishanam and advance kar seasons.

Banana and betel cultivation. Bananas have become a major crop, particularly in the tail of the system. The area devoted to banana has grown from about 11 percent of the registered command area in 1970 to 36 percent today (table 2). Betel has also become an important crop, although it is grown in a relatively small area in the tail. Bananas and betel grow year-round; they are not planted or harvested on a seasonal schedule. Both crops require year-round watering. During kar and pishanam seasons, farmers generally do not irrigate bananas because the seepage from the rice fields is sufficient. Problems arise during the hot, rainless months of April and May when no water is issued for rice cultivation unless the area is under advance kar rice

TABLE 2.
Area (ha) of rice and non-rice crops grown during pishanam season.

Reach	Command area	Rice	Bananas and other crops[a]
Head	2,335	1,195	1,140
Middle	13,925	12,880	1,045
Tail	18,674	8,374	10,300
Total	34,934	22,449	12,485

[a]Non-rice crops are overwhelmingly bananas during pishanam season.

cultivation. If irrigation is not provided at this time, the bananas are small and yields are reduced 20 to 50 percent. Although some banana and betel farmers use groundwater or water remaining in system tanks during this period, most depend upon deliveries from the canals.

Increased irrigated area. Although the registered command—the area recognized by the government as having rights to irrigation water from the Tambraparani Irrigation System—is 34,934 hectares, the estimates of the area actually irrigated range from 38,000 to over 41,000 hectares.

Industry. There has been significant industrial development around the city of Tuticorin in the Tambraparani tail area. In the early 1950s, only one plant drew water from the river. At present, six major industrial plants and a thermal power station draw 48.3 million cubic meters of water annually from the Tambraparani Irrigation System. There also are smaller industrial users of water located in various places in the system.

Municipal water supply. Individuals have long used the water in the Tambraparani channels and system tanks for their domestic needs. However, in the 1950s the only municipal use was by Tuticorin city, which used 7 million cubic meters annually. Now there are 48 municipal water supply schemes drawing water from the river, and several more are under construction. The Tamil Nadu Water Supply and Drainage Board estimates that the current and proposed municipal water supply schemes will require 25.5 million cubic meters per year.

Because of these changes, the overall demand for water has increased; the total command area has grown at least 10 percent, and industrial and municipal use has increased from 2 percent to 14 percent of the water releases from the reservoirs. Also, there is now a large demand for water releases year-round—including April and May, the months when the system was traditionally closed—for municipal and industrial uses, for advance kar rice, and for banana and betel cultivation. But the water distribution rules for the Tambraparani Irrigation System do not match these changed demands.

The Tambraparani Water Distribution Rules

The Tambraparani Irrigation System provides water for irrigation, power generation, municipal water supplies, and industry. The overall management of the system is correspondingly complex. The main actors in managing the system are the Public Works Department, Tamil Nadu Electricity Board, the district collectors, the water users associations, and the farmers. Only the first three are recognized in the formal water distribution rules.

Public Works Department. The irrigation wing of the Tamil Nadu's Public Works Department (PWD) (since October 1995 called the Water Resources Organization) is responsible for operation and maintenance of the Tambraparani Irrigation System except for some items specifically under the control of other entities. Operation and maintenance of the system are the responsibility of an executive engineer. He is assisted by various subordinates, including subdivisional officers, sectional officers, irrigation inspectors and *laskars* (gate operators). Laskars are the lowest-level PWD employees. Each laskar is responsible for the operation of a channel head sluice or of all the sluices within a reach of one of the channels.

Tamil Nadu Electricity Board. The Tamil Nadu Electricity Board operates the Papanasam and Servalar reservoirs and powerhouses. A divisional engineer is responsible for operations.

District collectors. The district collector, who comes under Tamil Nadu's Revenue Department, is the highest civil authority within a district. He plays important roles in irrigation system management, mostly in ratifying allocation and other decisions. Until the 1970s, the whole Tambraparani Irrigation System fell into Tirunelveli District. Since then, the area has been divided into the Tirunelveli-Kattabomman and Chidambaranar districts.

Water users associations. Unlike other irrigation systems in India, the Tambraparani Irrigation System has a large number of locally recognized water users associations (WUAs). The tail reach of the system has 90 WUAs while the head and middle reaches have 42. All have been formed spontaneously by the farmers themselves. Most are based on villages, but some are based on channels, castes, or crops (banana growers' association, betel growers' association), or are politically affiliated. All deal with water management; many carry out operation and maintenance functions below system tanks or on channels. Most have other functions including lobbying to get water to their channels or tanks. However, despite their importance in system management, there are no established occasions on which the government officials and representatives of the WUAs meet to discuss system management issues.

Farmers. Individual farmers and informal farmer groups strongly influence key aspects of system management. However, the management system officially recognizes individual farmers only through monthly "irrigation grievances days" held by the district collectors and at which individual farmers are invited to present their problems.

Sources of Tambraparani water distribution rules

Formally codified system distribution rules are a feature of the management of large irrigation systems in Tamil Nadu; sets of rules have been prepared for all 18 major systems in the state. Some—the "rules of regulation"—have been issued by the state cabinet of ministers. Others are issued by the district collector or by top-level PWD officials.

There are five major sets of water distribution rules for the Tambraparani Irrigation System.

- *The Channel Operating Rules* for the 11 channels were first prepared during the nineteenth century; the most recent amendments were made by the district collector in 1935.
- *Rules of Regulation for the Papanasam Reservoir* were first framed in 1960 and finally approved in 1977. It is expected that the Papanasam rules of regulation will be amended to incorporate operations of the Servalar Reservoir.
- *Rules of Regulation for the Manimuthar Reservoir* were approved in 1966 and amended in 1971 and in 1973.
- A 1969 letter from the PWD to the Tirunelveli district collector specifies a set of rules pertaining to authorization for advance kar rice cultivation.
- PWD general operating manuals and recorded decisions about the Tambraparani Irrigation System operations over more than a century define rules for handling many water distribution decisions.

There are other formal water distribution rules that apply to small portions of the irrigation system or to particular conditions. These include, among others, the several agreements under which the system supplies water to industries and municipalities and a 1987 government order permitting special releases during April and May to betel cultivators in the tail of the system. Rather than explicate each set of rules separately, we will summarize the rules concerning the major functions of the system.

Water distribution rules for nonagricultural purposes

Municipal and industrial distribution. Water distribution for industrial and municipal purposes is defined by agreements between the government and the users. These agreements are very specific, defining how much water is to be supplied, when, and to what place. For example, the agreement for the Tuticorin industrial park specifies that the system must deliver 20 million imperial gallons per day (1.13 m^3/s) throughout the year to Arumugamangalam Tank under the North Main Channel. These agreements are made with the state government. It is the PWD's duty, as the general manager of the system, to implement the agreements.

Power generation. The Papanasam Reservoir rules of regulation cover the operation of the reservoir for both power generation and irrigation purposes. These rules are described later (under Rules for Irrigation Scheduling and Operations). Rules have not yet been framed for Servalar Reservoir. However, as explained later, the two reservoirs are currently operated as one unit under the Papanasam rules of regulation.

Water allocation rules for irrigation

Basic principles. Irrigation distribution is much more complicated than is distribution for other uses. First, there are many more users—thousands of farmers versus one hydropower user and less than 100 municipal and industrial users. Second, the total demand is much higher because irrigation requires a great deal of water. Third, high demand means that the allocation rules must provide ways to balance supply and demand.

Tambraparani irrigation allocation rules are based on two principles:

- Water is allocated for irrigation for the recognized crop seasons: pishanam, kar, and advance kar.
- Irrigation water is allocated for rice cultivation.

Allocations for irrigation are defined by the authorization of irrigation of rice for a location within the system for a particular season. The amount of land that can be irrigated is defined by the needs of rice. For Tambraparani, the quantity required by rice is defined for each season; for kar and advance kar seasons PWD engineers use the rule that a million cubic feet of water will irrigate 6 acres of rice (equivalent to 11,646 m^3/ha).[2] Less water is required during pishanam season when rainfall is heavier.

Pishanam season. The sources of pishanam allocation rules are the Tamil Nadu land classification rules and PWD documented practices. Heavy rainfall ensures that sufficient water is available for the whole command. Consequently, the State of Tamil Nadu has classified the whole command as having a right to irrigation water for pishanam season irrespective of water availability. This principle is also reflected in records of PWD practice. Thus, there are only two allocation rules for pishanam season:

- The season begins around mid-October each year and ends during the following March.
- During the season, the whole command is allocated water for rice.

Kar season. The sources for kar season allocation rules are PWD regulations and documented practices. In contrast with pishanam season, water is often not sufficient for the whole command during kar season, and allocation to different parts of the command must be carried out each year. District collectors are involved by state law to safeguard the farmers' interests. The basic rules:

- Kar season begins on 1 June (formally decided in a 1992 court decision) and ends around 30 September each year.
- The PWD executive engineer is to authorize areas for rice cultivation based on the area that can be irrigated with the available water. Areas are authorized in priority order from the head of the system downward.
- The allocation decision must be ratified and publicized by the district collectors.

To make the allocation decision, the PWD executive engineer assesses water availability for kar season during the last week of May, taking into account storage in the main reservoirs and probable inflows. The executive engineer then calculates the area that can be irrigated with the estimated available water using the factor of 6 acres per million cubic feet of water. Cultivation of irrigated rice is then authorized in areas under channels beginning from the headmost channel and moving down the system until the calculated total area that can be irrigated is reached. The executive engineer selects a date for water release. For the first areas authorized, this date must be about 1 June. He forwards his allocation decision to the district collectors who ratify it to make it official and then publicize it. The executive engineer may go through this procedure more than once if in his judgment water availability improves during June and July.

Advance kar season. The advance kar season allocation rules are defined in a 1969 letter to the district collector from the PWD:

[2]In fact, the engineers say their goal is to reach 7 acres per million cubic feet of water (100 ha/10^6 m^3), but they use the figure reported here for practical reasons. For historical reasons, English units rather than metric units are customarily used in the water distribution rules.

- The command under the last four channels of the system (last two anicuts) is divided into four explicitly defined priority subareas. The first priority area includes the land under the two largest tanks in the South Main Channel command, whereas land under other tanks in the same channel command fall into the second or third priority areas. Land under the North Main Channel is also divided into first, second, and third priority areas. Land under the other two channels is defined as the fourth priority area.
- On 15 March, the executive engineer is to allocate water to these areas in priority order based on his estimate of water availability for the season.
- Water allocated for the advance kar cultivation must leave at least 500 million cubic feet of water (19 million m^3) available in the Papanasam Reservoir on 1 June for kar season cultivation.

An additional rule, implied but not stated in the 1969 letter, is that the advance kar season begins on 1 April and ends around the end of July. The rules do not require formal ratification of the allocation decision by the district collector.

Although there is less rainfall during the advance kar season than during the kar season, the PWD executive engineer uses the same ratio of 6 acres per million cubic feet of water to calculate the area that can be irrigated.

Rules for irrigation scheduling and operations

Once allocations are made, there is a need to deliver the water according to a schedule. In Tambraparani, scheduling is carried out at three levels: along each of the 11 channels, on the main system (the river) to the 11 channels, and from the reservoirs. The rules apply to all three seasons.

Scheduling along the channels. The 1935 Channel Operating Rules provide explicit instructions for water deliveries along each of the 11 channels. For example, the operating rules for the Nadhiyunni Channel at the second anicut specify that water delivery is to be by a 5-day turn system that rotates water among four defined subareas. Detailed times for starting delivery for each area and the duration of the delivery are given. The rules also specify the levels to be maintained at key points and indicate where temporary dams are to be erected. For channels that have system tanks, the rules specify the order of filling of the tanks.

Scheduling on the main system. Scheduling of water deliveries to the channels is defined through PWD regulations and operating principles. The basic principle is that demand for each channel is to be determined every day, and flows in the main system are to be adjusted daily to meet the demands. It is assumed that the allocation rules have ensured that there is enough water for the season and that the daily demands are evaluated correctly.

To implement the basic principle, PWD operating rules require the laskars on each channel to survey and keep track of the crop conditions under the channel. Every day, each laskar who operates a channel head gate is required to estimate the water needed by the crops served by his channel. Each morning, he is supposed to forward his demand estimate to the executive engineer through the PWD hierarchy. The executive engineer then is to issue orders for gate settings at the reservoirs, channel heads, etc., to match the combined demands. These orders are to be passed down through the hierarchy to the laskars responsible for operating the control structures.

Besides the general operating rules, there are more specific operating rules. Water is to be delivered to the channels continuously for the first 2 weeks of each season for seedbed preparation and planting. After the first 2 weeks, water is to be delivered continuously to the channels if enough is available or else the water is to be rotated among channels on a schedule set by the executive engineer. Rotational deliveries should be made first to the channels with large areas under system tanks so that those responsible for the system tanks can handle irrigation needs during off periods. To conserve water, deliveries are to be reduced appropriately when rain falls.

PWD freedom to deviate from the rules. The executive engineer has considerable freedom to deviate from rules and schedules. The Channel Operating Rules explicitly authorize the executive engineer to modify operations within the channels as he judges necessary. Also, a 1938 instruction from the chief engineer, irrigation, of the PWD permits the executive engineer to modify schedules to protect crops that are "in immediate danger of withering."

Operation of the Papanasam and Servalar reservoirs. The Papanasam Reservoir rules of regulation define the operation of the reservoir for irrigation as well as power generation:

- Papanasam Reservoir operation is assigned to the TNEB divisional engineer. Operation of the powerhouse is assigned to the TNEB by state law.
- The Papanasam powerhouse is allocated 1,400 cusecs[3] (39.6 m^3/s) of flow throughout the year. This flow is the maximum intake of the powerhouse.
- The TNEB is permitted to impound flows above 1,400 cusecs in the reservoir for later use.
- Irrigation requirements from 1 to 15 June are 1,650 cusecs (46.7 m^3/s), and from 16 June through 31 March they are 2,300 cusecs (65.1 m^3/s). Inflows to these limits are allocated to irrigation, but inflows above these limits are allocated to the TNEB for power generation. Accounting is to be done monthly.
- The PWD executive engineer may request the TNEB divisional engineer to release the water allocated to irrigation, after deducting water lost through evaporation, whenever needed for irrigation.
- Because the maximum intake into the Papanasam powerhouse is 1,400 cusecs, discharges into the river from the reservoirs are "generally" limited to that rate.

All releases are actually made from the Servalar Reservoir, as explained later.

Operation of the Manimuthar Reservoir. The Manimuthar River joins the Tambraparani at the Kannadian Anicut (the third anicut). The Manimuthar Reservoir on the Manimuthar River serves the dual purpose of providing irrigation water to 349 tanks in its own command and of regulating supplies for the Tambraparani Irrigation System. The PWD executive engineer for Tambraparani is responsible for operating the Manimuthar Reservoir. The Rules of Regulation for the Manimuthar Reservoir divide water between the two systems.

The amount of Manimuthar River water that can be drawn upon for the Tambraparani Irrigation System is limited to an annual total of 51 million cubic meters. The remainder of the Manimuthar water is to be used for the Manimuthar Reservoir command through the High Level Canal.

When the Tambraparani River flow at the Kannadian Anicut exceeds specified limits for different periods of the year, the

[3]Cubic feet per second. The numbers given in the water distribution rules in the Tambraparani Irrigation System are generally specified in English units.

full flow in the Manimuthar River is to be impounded in the reservoir for the Manimuthar command.

If the flow at the Kannadian Anicut is less than the specified limits, the deficit is to be made up from the natural flow of the Manimuthar River. The remainder of the Manimuthar River flow, if any, is to be impounded in the reservoir for the Manimuthar command.

If the flow at the Kannadian Anicut is less than the specified limits but water is not needed in the lower portions of the Tambraparani command, then the executive engineer may choose to impound the Manimuthar River water that would go to Tambraparani in the reservoir and draw upon it for the Tambraparani command at a later time.

Deficiencies in the distribution rules

The Tambraparani water distribution rules have two major deficiencies: they are internally inconsistent,[4] and they define a pattern of water deliveries that does not match the goals of a large group of users.

Inconsistencies in the rules. According to the rules, flows in the main system are to be adjusted daily to meet demands from the channels. However, the rules for operating the channels rigidly prescribe delivery schedules and levels to be maintained. Rigid schedules with varying flows mean that those lucky enough to get their turns when flow is high get extra water while those whose turns come when flow is low get little. This inconsistency forces the laskars responsible for operation of the channels to choose whether to ignore the channel operating rules or to frame their demands to facilitate operating the channel according to the rules. In the latter case, their ability to implement the channel operating rules depends upon the ability of the main system managers to deliver water according to demand.

The Papanasam Reservoir rules of regulation say that discharge from the reservoir is to be "generally" limited to the 1,400 cusecs (39.6 m^3/s) that can be used by the Papanasam powerhouse even though this is far below the maximum irrigation demand. The rules also place some water in the reservoir under the control of the PWD executive engineer to meet irrigation demands above the 1,400 cusecs. He cannot use this water unless reservoir releases exceed 1,400 cusecs. If the TNEB, which operates the Papanasam and Servalar reservoirs, insists on interpreting the term "generally" to restrict the releases to 1,400 cusecs, the ability of the PWD executive engineer to respond to daily demands from the laskars is severely limited.

The Manimuthar Reservoir rules of regulation say that the Manimuthar River flows are to be used to assure sufficient flow in the Tambraparani River. The rules also set an absolute annual limit of 51 million cubic meters of water that may be taken from the Manimuthar Reservoir for the Tambraparani Irrigation System. If flows in the Tambraparani River are low, it may not be possible to satisfy both of these rules. Either Manimuthar River water will be used for the Manimuthar command and flow will not be maintained in the Tambraparani River or the limit of contribution of Manimuthar River water to the Tambraparani Irrigation System will be exceeded. The first case may deprive Tambraparani farmers of expected water; the second may deprive Manimuthar command farmers.

The flow in the Tambraparani River is determined to a large extent by releases from the Papanasam and Servalar reservoirs. Thus, the more strictly a limit on Papanasam Reservoir releases is observed, the greater the

[4]In his comments on a draft version of this paper, S. G. Narayanamurthy pointed out that water distribution rules must satisfy certain consistency and information conditions: (1) rules should be consistent with the objectives of the system, (2) rules should be consistent with the rules at higher levels in the hierarchy, (3) each rule must be based on information likely to be available for decision making when the rule is to be applied, (4) discretion granted by a rule to a decision maker should be limited to competence likely to be available at that point, (5) the range of possible version decisions should be one that can be implemented with reasonable faithfulness on the physical system, and (6) the rules must be seen to be taking all important factors into consideration and thus indicate competent management.

probability that one or the other Manimuthar Reservoir rule will be broken.

Mismatch with farmers' goals. Many farmers plant bananas because they are far more profitable than rice (Pundarikanthan et al. 1992). But the rules make no provision for allocating water to bananas although the crop occupies over a third of the command. Bananas require year-round water delivery, particularly in April and May, rather than delivery only during two rice seasons. Satisfying the desire for water for bananas is perceived as feasible because the total water requirement for bananas is less than the water requirement for two rice crops (Pundarikanthan et al. 1992). All that is needed is a change in delivery schedules.

Change as the cause of the deficiencies. Both types of deficiencies are products of the changes undergone by the Tambraparani Irrigation System over time. As the system grew, government authorities codified water distribution rules for various parts of the system without careful consideration of existing rules, leading to inconsistencies.

The mismatch of the rules with the farmers' goals is also a product of the shifting opportunities for agricultural production without concomitant changing of the rules.

Flexibility in the water distribution rules

Water distribution rules must allow for adaptation of distribution to varying water supply, water demand, and other conditions.

The Tambraparani rules provide flexibility by:

- Specifying that the PWD executive engineer makes seasonal allocations for kar and advance kar seasons based on his estimate of water availability in the season.
- Specifying that the main system deliveries to each channel are to be set each day to meet channel demand as specified by the laskars. Actual deliveries are specified by the executive engineer's office.
- Permitting the executive engineer to change channel operations as he feels is necessary.
- Giving the executive engineer power to issue water to crops "in danger of withering."
- Giving the TNEB divisional engineer power to release water from the Papanasam Reservoir as needed for hydropower generation.
- Giving the PWD executive engineer power to divide Manimuthar River water between the Manimuthar command and the Tambraparani Irrigation System.

Obviously the flexibility lies almost entirely in the hands of the PWD executive engineer. Most decisions rest on his judgment alone. Under the rules, he is not answerable to the users; he is answerable only to his superiors within the PWD. While these rules provide flexibility, they also allow the executive engineer and his advisors considerable scope for abuse or incompetent execution of the rules.

Actual Water Distribution in Tambraparani

We have pointed out that there are major inconsistencies in the water distribution rules and that the rules define a pattern of water deliveries that does not match the farmers' goals. In addition, we have hypothesized that, if the water distribution rules do not match technically feasible goals of the users, then the users, often in cooperation with system managers, will modify or subvert the rules to bring water delivery into accordance with their desires. We also hypothesized that inconsistencies in the rules will cause difficulties in operations. This section shows that both hypotheses are true for the Tambraparani Irrigation System.

Reservoir operations

To deliver water to the channels as required for irrigation, the PWD executive engineer has to draw the required flows from the reservoirs, primarily the Papanasam and Servalar reservoirs. The required discharge varies daily, but, during kar and advance kar seasons, the required discharge from the reservoirs can be well above 2,000 cusecs (56.6 m^3/s).

The Papanasam and Servalar reservoirs are operated by the divisional engineer of TNEB. The Papanasam Reservoir operating rules allocate some inflow into the reservoirs to irrigation and specify that the PWD executive engineer can request the water from TNEB's divisional engineer when needed.

The TNEB interest is power generation; it wants all available water to flow through the two powerhouses to generate electricity. To generate power, the board runs water from the Papanasam Reservoir through the tunnel connecting the two reservoirs and makes all releases through the Servalar powerhouse. The water flows down the Servalar River to its confluence with the Tambraparani River and then flows through the Papanasam powerhouse below the confluence. In this way, the TNEB uses all the water in both reservoirs to generate power twice.

Although the Servalar powerhouse intake can handle up to 2,200 cusecs (62.3 m^3/s), the older Papanasam powerhouse intake can handle only 1,400 cusecs. If the TNEB divisional engineer releases more than 1,400 cusecs, the excess will spill over the Papanasam powerhouse weir without generating electricity. To prevent this, the TNEB has ordered its divisional engineer not to allow water over the Papanasam powerhouse diversion weir without *written* permission from the TNEB chairman in Madras.

These operating practices prevent the flexible use of reservoir water for irrigation as required by the main system operating rules. Even if the TNEB chairman is willing to give permission for releases exceeding 1,400 cusecs, it takes time to get the permission, making it impossible to deliver irrigation water responsively in periods of heavy demand. In practice, the TNEB divisional engineer occasionally permits spilling of water over the Papanasam powerhouse diversion weir for a day or two. This practice softens the effects of the restriction but does not overcome them.

When the required discharge for irrigation is not available from the Papanasam powerhouse weir, the PWD executive engineer is forced to use the Manimuthar River water to meet the shortage as specified in the Manimuthar Reservoir rules. However, the Manimuthar rules also limit the total annual draw from the Manimuthar River for the Tambraparani Irrigation System to

51 million cubic meters. The remainder of the water is to be used for 349 tanks fed through the Manimuthar High Level Canal. Yet, because of restrictions of flow from the upper reservoirs, the executive engineer generally has to use more than the limit for the Tambraparani Irrigation System. The Manimuthar River water used for the Tambraparani Irrigation System has exceeded the limit of 51 million cubic meters in 22 out of the 34 years before 1993. As a result of supplying water for the Tambraparani command, the Manimuthar Reservoir has frequently not had a high enough level to provide water for the Manimuthar High Level Canal command. That is, the Manimuthar command has been starved to provide water for the Tambraparani command.

Main system operations

The distribution rules require PWD officials to adapt water deliveries to demand every day. The only major variation is that deliveries are reduced following rainfall. However, the daily operating decisions are only as good as the information on which they are based.

Information on crops and cropped area is not good. Laskars are supposed to survey the crops and report areas under each crop and areas irrigated. In fact, most of them use the figures collected by the Revenue Department officers.

Information on the area under bananas is particularly suspect. Because advance kar water issues are meant only for rice, laskars are reluctant to report that bananas are being irrigated. Because banana area figures from the laskars cannot be trusted, the area under banana in the lower reaches of the system is estimated from demands for special releases for water. Also, when calculating water demand for the kar season, the executive engineer's office ignores the area under bananas.

Information on water flows is scanty; discharges are measured only at the reservoirs, the anicuts, and the heads of the channels.

Because of reuse, the quantity of water let into the channels is always greater that the quantity released from the reservoirs. However, return flow is ignored in daily decision making.

Rainfall figures are collected each week from five gauging stations in the command. These figures are useless for daily operational adjustments. Therefore, responses to rainfall are based purely on the observations and local judgment of each subdivisional officer.

Laskars' reports of gauge readings at channel heads and their demands for water releases are communicated to higher-level PWD officers daily via canal phones. The only records routinely kept are the laskars' field books in which discharges at the anicuts and channel heads are recorded.

These practices give great power to the laskars. Although decisions about daily deliveries to the channels are made by higher-level PWD officials, those decisions are based on demands for irrigation water that originate from the laskars. These demands are justified by crop and water information that also originates from the laskars. Only the laskars keep records of deliveries. Therefore, there is no way to check the cumulative amount delivered to each channel against the amount allocated for the season. Even if records were kept, the rule requiring that standing crops be saved from damage would prevent PWD officials from cutting off water to a channel.

On the other hand, PWD officials have major difficulties satisfying the laskars' demands because of the restrictions on discharge from the reservoirs. Main system operating decisions are daily compromises between what the laskars demand and what is possible in view of the restrictions on river flow. As a result the main system water deliveries are not predictable.

For example, all PWD personnel try to keep water flowing into the Nadhiyunni Channel continuously during kar and pishanam seasons because there are no tanks to provide water to the crops when there is none flowing in the channel. Table 3 shows that the PWD is unsuccessful. In the South Main Channel, actual operations also differ widely from the nominal pattern (table 3). The operating plan for the last anicut is to deliver water alternately to the South Main Channel and to the North Main Channel for 7 days each. In fact, water is diverted into both channels when the level at the anicut is high and there is need for water in the tanks fed by these channels.

TABLE 3.
Examples of main system operations.

Channel	Season	Nominal operations pattern (days)	Range of turn length (days)	Delivery days /total days	Design discharge (cusecs)	Actual discharges (cusecs)
Nadhiyunni	1992 kar	continuous	2–35	124/154	95	30–79
	1992–93 pishanam	continuous	3–20	102/168	95	44–95
South Main	1992–93 pishanam	7 on, 7 off	17–33	68/168	n.a.	n.a.
	1993 advance kar	7 on, 7 off	3–31	75/~125[a]	n.a.	n.a.

[a]In addition, releases totaling 14 days were made in August for "domestic purposes."

Operation of the channels

Although the Channel Operating Rules give detailed rules for water distribution along the channels, actual distribution is quite different. The key actors in deciding how water is distributed are the laskars, the farmers, and the water users associations.

Laskars and farmers. Laskars are responsible for operating gates to distribute water along the channels. The rigid Channel Operating Rules would seem to greatly limit the decision-making powers of laskars. But, in fact, laskars are loosely supervised. They have few direct supervisors, and the supervisors rarely visit the field or notice deviations from the rules. Laskars use their freedom of action to respond to farmer requests for water. In return, farmers make gifts of rice and other items to the laskars, and sometimes pay them for service. Farmers also become involved in distribution of water through direct action, such as by pumping water from canals. Direct action, too, requires the cooperation of the laskar because he is empowered to stop it or to report the farmers to the authorities who can fine them.

For example, PWD regulations say that the one laskar assigned to the Nadhiyunni Channel is supposed to travel the length of the canal each day to adjust gates according to the Channel Operating Rules. Instead, the laskar visits and adjusts gates only after being called by a farmer. The Nadhiyunni farmers report that a laskar who retired in 1994 used to demand Rs 100 to adjust a gate (the present laskar does not demand money for this service).

Despite such demands, most farmers look upon the laskar as the person responsible for getting sufficient water; many farmers develop close associations with the laskar. Farmers who are faced with water problems come to the laskar for solutions. The laskar generally tries to get enough water to satisfy the farmers of the channel through the daily demands he sends to his superiors. By adjusting gates as requested, he attempts to apportion the available water in such a way that most farmers are satisfied. In return for this service, farmers give rice to the laskar at the end of the season. The Nadhiyunni Channel laskar is estimated to collect 1,000 to 1,500 kilograms of rice per season, an amount equivalent to more than half his PWD annual salary.

There are eight laskars assigned to South Main Channel at the last anicut. The laskars are responsible for operating the sluices from the channels to the tanks and to the direct command area; they are not responsible for distribution of water below the system tanks or below the direct sluices. Distribution in these areas is handled by water users associations (WUAs) or by the farmers themselves. As in the Nadhiyunni Channel, farmers who get water directly from the channel go to the laskars for help when they have problems. WUA leaders go to the laskars to get water for their tanks.

In return for help, farmers voluntarily give gifts to the laskars. Most give rice through the WUAs. Farmers report that WUAs give the laskars 35 to 70 kilograms of unhusked rice each season and that individual farmers in the direct command give 3 to 5 kilograms of unhusked rice or a couple of bunches of bananas each season. When the actions requested of the laskar are clearly against the rules, laskars may demand cash or farmers may offer it. Direct command farmers report paying cash to the laskar to close a cross regulator against the rules. Others report paying a laskar to provide water during April and May for unauthorized land or to overlook pumping from the channel.

Loyalty of the laskars. Gifts and payments to laskars are an old practice. In parts of Tamil Nadu, including areas under many of the system tanks in Tambraparani, irrigators are appointed and paid by farmers. Generally, these irrigators are paid part of the rice harvest. Hence, gifts of rice to laskars can be viewed as a continuation of traditional irrigation practices. Today, laskars encourage the practice. During informal talks, a number of laskars expressed strong dissatisfaction with the PWD over pay, retirement benefits, and traveling allowances. Laskars feel they have good reasons for choosing to work with farmers. The current pressure on the water supply has resulted in increasing the laskars' importance as a means for getting water. One result is that many farmers feel they now have to pay to be sure they get their water.

Water users associations. WUAs help acquire and distribute water for their areas, undertake channel maintenance, and take on other functions. WUAs generally cooperate with laskars to get water for system tanks and for canals in the direct command. For example, there are three village-based WUAs in the Nadhiyunni Channel command. All take active roles in management, particularly in channel maintenance. The two WUAs located at the tail of the channel provide labor for cleaning the upper portions of the Nadhiyunni Channel to get water to their areas.

There are about 35 WUAs in the South Main Channel command. Most are based on villages, although some include more than one village and some villages do not have a WUA. One WUA is an association of betel farmers. Some WUAs are based on tanks. WUAs are totally responsible for water distribution from the 15 tanks in the command; they maintain the tank systems, help in obtaining water for the tanks, and undertake other activities. The few WUAs in the direct channel command work with laskars to get water.

WUAs take part in conflicts over water, particularly conflicts among farmers from different tanks. For example, during periods of shortage, the Ammanpuram Tank WUA organizes farmers to block the sluice of the Natham Tank supply channel. During shortage periods, other WUAs hire guards to patrol their supply channels to prevent such occurrences. A recent major conflict occurred between farmers of the Kadamba Tank and farmers of 12 tanks fed through the Kadamba Tank. To help in delivering water to these tanks, the PWD proposed building a channel to bypass the Kadamba Tank. To defend the Kadamba Tank's privileged position, the Kadamba Tank Protection Council was formed in 1991. This council took members' concerns to court while the WUAs from the downstream tanks defended the bypass. In a verdict rendered in 1994, the court allowed construction of the bypass but required measures to safeguard the rights of the Kadamba Tank farmers.

Relevance of the Channel Operating Rules. Clearly, the detailed Channel Operating Rules for distributing water along the channels have little relevance to actual operations on the channels. Laskars and farmers make the operating decisions in response to immediate needs. This is a logical response to the unpredictability of deliveries to the channels by the main system.

Water allocations in practice

Seasonal allocations. The rules say that all of the Tambraparani command is allocated water for rice during pishanam season. According to PWD records, from 1971–72 through 1992–93, all 34,934 hectares of the registered area had been irrigated and harvested during pishanam season.

The rules for kar season say that the PWD executive engineer makes an initial allocation before the season and then can add to the allocation later if he finds that water availability has improved. During May 1993, for example, the PWD authorized kar season irrigation for 7,290 hectares under the first four channels, with issues beginning on 1 June. An additional area of 2,429 hectares under the fifth channel was authorized, and issues began on 19 July. Based on further improved storage levels, issues were begun on 23 July for the sixth channel (1,417 ha) and part of the seventh channel (810 ha). No additional area was authorized for kar 1993.

Adding to the kar season allocations is common: PWD records show that it was done eight times from 1979 through 1992. Over this 14-year period, the average initially authorized area was 19,974 hectares, but the average final authorized area was 25,121 hectares. Government records indicate that the areas authorized are very close to the areas harvested.

The rules for advance kar season say that the PWD executive engineer is to allocate water for rice to specific areas in the tail of the system in a defined priority order. PWD records show that the authorized area for advance kar season varies greatly. From 1977 to 1989, advance kar authorizations ranged from 0 to 18,660 hectares and averaged 5,167 hectares.

However, advance kar season allocations are heavily influenced by the farmers in the tail area, and the actual area irrigated is likely to be much greater than authorized. For example, official government figures for 1994–95, a year with above-normal water availability, show that advance kar rice was authorized for the maximum area in the South Main Channel permitted by the rules—4,500 hectares. Official figures show that rice was planted in the whole 5,166-hectare command of the South Main Channel along with over 2,800 hectares of ba-

TABLE 4.
Crop area (ha) reported by the government in the Tambraparani Irrigation System, 1994–95.

Anicut	Channel	Registered command	Rice area: Pishanam	Rice area: Kar	Rice area: Advance kar	Bananas	Kar pulses[a]
Kodaimelalagian	South Kodaimelalagian	357	348	348	-	38	-
	North Kodaimelalagian	925	904	904	-	65	-
Nadhiyunni	Nadhiyunni	1,053	984	984	-	28	-
Kannadian	Kannadian	5,058	5,000	5,000	-	275	-
Ariyanayakipuram	Kodagan	2,428	2,400	2,208	-	-	-
Palavoor	Palayam	3,845	3,800	3,525	-	35	-
Suthamalli	Tirunelveli	2,594	2,564	2,564	-	-	-
Marudur	Marudur Melakkal	5,173	2,150	-	2,200	1,350	1,850
	Marudur Keelakkal	3,154	1,550	-	1,600	510	1,260
Srivaikundam	South Main	5,166	5,436	-	5,166	2,854	-
	North Main	5,181	3,373	-	2,161	3,936	-
Total		34,934	28,509	15,533	11,127	9,091	3,110

[a]Nonirrigated.

nanas (table 4). Interviews with farmers suggest that rice was planted in less than the reported area.

The total area officially reported under advance kar rice in the last four channels was 11,127 hectares (table 4), somewhat less than the 13,617 hectares officially authorized for advance kar for these channels. But the sum of the banana areas under the last four channels and the reported advance kar rice areas is 19,777 hectares, well above the authorized area.

If these figures are correct, they imply that a much larger area was irrigated during advance kar than was authorized. It may also be that the rice area is exaggerated, as it seems to have been for South Main Channel, to conceal the advance kar water issues used for bananas. Possibly both are true: more area was irrigated than was authorized and the rice areas were padded to justify the authorizations.

Solving shortages in the tail. Bananas and betel are concentrated in the tail of the system; hence in these areas the demand for year-round water is greatest. During pishanam season, the channels get adequate irrigation water to supplement the northeast monsoon rains. But during the rest of the year, particularly from April to June when rain seldom falls, water is often scarce. Shortages are met by getting special releases, through pumping, and by getting advance kar allocations.

Mobilizing pressure for special releases of water during shortage periods is a major function of the WUAs. Examples are a request by betel growers for special releases for their crops under a 1987 government order, a request by farmers under the Avudayar Tank for special releases for the Thiruchendur Temple, and requests for special releases for “domestic purposes,” i.e., drinking water. In all cases, the water is used for standing crops, particularly betel and banana.

When special releases are required, the WUAs under each tank meet and fix the contribution each farmer has to make. Rates are determined by the intensity of the problem and the likely expenditure. Generally, the rate is Rs 1 per banana plant or Rs 150 per acre (Rs 370/ha) of betel or banana. These funds are used to send WUA leaders to Tirunelveli and Madras to persuade legislators and senior bureaucrats to grant special releases, sometimes through gifts to these individuals.

Because groundwater use is unregulated, pumping groundwater is a solution for farmers who have access to wells with good quality water. However, few farmers have good quality groundwater. The alternative, pumping from the canal, diminishes flows intended for other uses such as industry or the special releases. Consequently, such pumping is against the rules, but can be done with the collaboration of the laskars. To supply 40 cusecs (1.13 m^3/s) of water to the Tuticorin industrial park, the PWD releases 150 to 160 cusecs (4.25 to 4.53 m^3/s) of water at the channel head every day. Most of the transmission losses are the result of over 300 farmers pumping water from the North Main Channel.

Requesting advance kar allocations is a major way of getting water for bananas in the tail of the system. To influence seasonal allocations, WUAs in the tail area send delegations to persuade government officials to authorize advance kar issues, particularly for second and third priority lands. The water is used for betel and banana crops although it is ostensibly released for rice. For example, in 1993, in the South Main Channel, the WUAs under six tanks on third priority land sent a farmer related to a member of Parliament to visit officials at district and state level. Through his connections, he convinced the state minister of the PWD to grant advance kar authorization for these six tanks.

Tail-end WUAs spend a considerable amount of money to get advance kar allocations or special releases to get water to their tanks during the shortage period. A leading farmer who is also a senior government official, estimates that one WUA annually collects Rs 65,000 to Rs 135,000 for this purpose. Of this, 20 percent is shared by the WUA leaders, 65 percent is distributed to officials at different levels, and the rest is spent on travel and other expenses. WUAs generally provide water obtained through such interventions only to farmers who contribute to the fund.

The WUAs also threaten or carry out public demonstrations to influence government officials. A popular means is to block a highway, particularly when an important official is scheduled to pass. In 1992, blocking a minister's car resulted in a special release desired by the farmers.

Through these means, the tail farmers have been generally successful in getting water for their banana and betel crops. There have been no reports of major crop failures despite widely varying allocations for advance kar cultivation.

Conflict over seasonal allocations. The success of the tail farmers in getting water has become a recognized problem for head and middle area farmers. Excess allocations for advance kar limit the amount of water available during kar season (Pundarikanthan et al. 1992) and special releases deliver more water to the tail than is allocated.

Kar season allocation rules give priority to the channels at the head of the system. However, farmers who receive advance kar allocations are able to get their crops in the ground before June when farmers in the head areas are just beginning kar season cultivation. If a water shortage occurs in June or July when the two seasons overlap, the tail areas get priority for water because they have endangered crops already in the ground. Thus, advance kar allocations reverse the traditional priority for allocation of water during these months. The reversal of priorities was probably the major factor in motivating tail farmers to agitate for advance kar allocations 40 years ago, even before bananas or betel became major crops.

In 1987, the Three Channel Association, representing the farmers of the first three channels of the Tambraparani Irrigation System was formed specifically to protect the allocation priority of the head area channels. The association filed charges alleging that the district collector and the PWD issued more water to the tail areas for advance kar than was allowed by the rules. They claimed that this practice resulted in the delay of issues for kar cultivation. A 1992 court judgment dismissed the farmers' allegations but ordered that water must be reserved for kar water releases as specified in the 1969 rules and that kar releases for the first three channels must begin on 1 June. These were the key points the head area farmers were fighting for.

Making water deliveries match goals

In Tambraparani, to allocate and deliver water as desired by farmers, various officials and farmers ignore and subvert the water distribution rules for irrigation. Among them are

- farmers and laskars who collaborate to serve the farmers' interests against other farmers or against the distribution rules
- farmers who, through their WUAs, put political and other pressure on government officials to authorize advance kar irrigation or to sanction special releases to get water to irrigate their bananas and betel
- system managers who cooperate with these farmers

Also the purposes of the water distribution rules are subverted by some system managers, such as the Tamil Nadu Electricity Board, which tries to prevent water releases for irrigation that do not generate electricity, and the PWD officials who issue water from the Manimuthar Reservoir to serve the needs of the Tambraparani Irrigation System against the clear intent of providing water for the Manimuthar Reservoir's own command.

Because of the evasions and subversion of the rules, the agricultural output of the Tambraparani Irrigation System is better, from the point of view of some farmers, than it would be if water were delivered according to the rules. Sticking to the rules would severely damage the banana and betel crops and would probably reduce the total value of the crops. Bananas produce significantly higher per hectare cash returns than do two rice crops. Pundarikanthan et al. (1992) estimate that in 1991 income from each rice crop was Rs 6,250/ha—or Rs 12,500/ha per year—while bananas produced an income of Rs 40,500/ha per year.

Also, the actions of the laskars, farmers, and WUAs in managing channel operations against the rules compensate in part for the main system delivery deficiencies and may keep rice yields higher than they might be otherwise.

Presumably, the TNEB restrictions on reservoir releases also have a benefit: they may help maintain power production when river flows are at their lowest.

Consequences of the Deficiencies in the Tambraparani Rules

Water delivery performance

Water delivery performance refers to the delivery of water to users or to specific points in the irrigation system in the correct amounts and at the correct times. Correct amounts and times are best judged by how close deliveries are to operating plans and operating goals. In the Tambraparani Irrigation System, as in most South Asian irrigation systems, equity of delivery is one of the goals of management; thus correct deliveries are those that deliver the same amount of water to each hectare throughout the system. Efficiency of delivery is another goal: only the necessary water should be delivered so that the excess can be used for other purposes.

Evaluating water delivery performance. To investigate performance in the Tambraparani Irrigation System, we arranged for the collection of detailed data on water deliveries to the 11 channels from 1 April 1994 through 31 March 1995 (Krishnan Associates 1995). Using this data, water distribution particulars for the year 1994–95 were calculated (table 5).

Water availability. The availability of water was higher than normal in 1994–95. The 11 channels received 1,621 million cubic meters at the channel heads—51 percent above the long-term average discharge volume of 1,074 million cubic meters. The maximum cultivated area reported was 40,710 hectares (sum of bananas, pishanam season rice, and pulses, which are not irri-

TABLE 5.
Main system water distribution performance of the Tambraparani Irrigation System, 1994–95.

Anicut	Channel	Rainfall (mm)	Design discharge (l/s/ha)	Maximum delivery[a] (%)	Days of flow[b] (mm)	Irrigation water req. (mm)	Water release[c] (%)	Efficiency[d]
Kodaimelalagian	South Kodaimelalagian	847	3.11	70	78	1,590	5,807	27
	North Kodaimelalagian	847	2.67	53	86	1,590	3,724	43
Nadhiyunni	Nadhiyunni	847	2.30	61	66	1,590	3,754	42
Kannadian	Kannadian	1,014	2.67	60	87	1,590	3,895	41
Ariyanayakipuram	Kodagan	1,014	4.48	82	84	1,630	9,797	17
Palavoor	Palayam	756	4.73	54	82	1,630	6,875	24
Suthamalli	Tirunelveli	756	2.30	47	84	1,630	2,870	57
Marudur	Marudur Melakkal	499	2.74	48	74	1,953	3,980	49
	Marudur Keelakkal	499	2.72	67	75	1,953	5,569	35
Srivaikundam	South Main	499	7.60	16	70	1,953	3,650	54
	North Main	499	5.90	23	86	1,953	4,261	46
Average		734		53	79	1,733	4,926	39[e]

[a]Maximum discharge during the season divided by design discharge.

[b]No. of days water was released into the channel divided by total no. of days in the season.

[c]Volume of water released into the channel divided by channel command area.

[d]Irrigation water requirement divided by water release.

[e]Arithmetic average of the channel efficiencies.

gated)—17 percent greater than the registered command of 34,934 hectares (table 4).

Deliveries to the channels. When there is sufficient water, as there was in 1994–95, the water distribution rules call for continuous delivery to the channels. However, none of the channels were operated continuously throughout any season. Days operated varied between 66 and 86 percent of the seasons. The reasons for not operating the channels continuously appear to be closure of channels to save water and protect the channels during periods of heavy rainfall; occasional rotational operation in some channels, such as the South Main and North Main channels; and inability to control discharges from the reservoirs.

The design discharges of the 11 channels range from 2.3 to 7.6 l/s/ha (20 to 75 mm/day). The South Main and North Main channels, being the tail-end channels, were designed as flood carriers, therefore they were designed to carry high flows. Some channels, such as the Kodagan and Palayam channels, receive large amounts of drainage, so their designed capacities were fairly high (4.5 to 4.7 l/s/ha). All other channels were designed for a flow of 2.3 to 3.1 l/s/ha.

During 1994–95, the maximum deliveries to all 11 channels were less than the design discharges—maximum deliveries ranged from 16 to 82 percent of the design discharges. A comparison of design discharge against deliveries indicates that there is no correlation between the two. As expected, the last two channels in the system (South Main and North Main channels) received very low percentages of their design discharges because they were designed to carry floods. However, it is not clear why, for example, Kodagan Channel received 82 percent of its design discharge.

Efficiency of delivery. The target annual delivery to the channel heads is 2,340 millimeters.[5] In 1994–95, the water supplied at the channel heads varied from 2,870 to 9,797 millimeters, or an excess of 23 to 219 percent. Annual crop water requirements for rice vary from 1,590 millimeters in the head reach to 1,953 millimeters in the tail reach. The water supplied was much greater than the requirements (fig. 3); efficiency of supply varied between 57 percent and 17 percent. One reason for the variations in efficiency is that maintenance has been neglected, and many channels are dilapidated and infested with weeds. Repair and good maintenance would improve channel conveyance efficiencies considerably. The Tirunelveli Channel had the highest efficiency, apparently due to recent channel improvement works under the National Water Management Project.

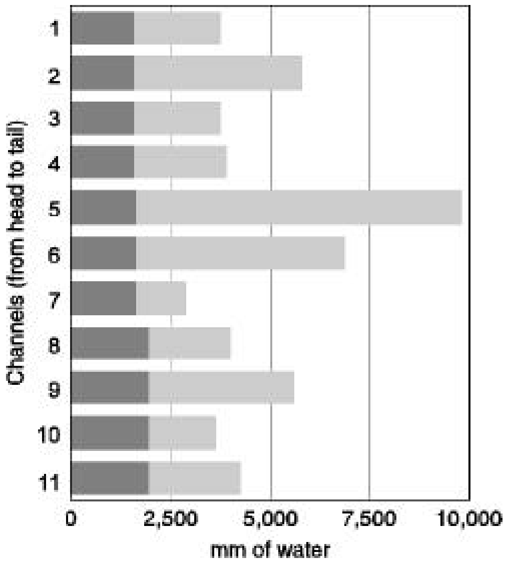
Also, drainage flows are ignored when planning operations; flows at some anicuts are higher than planned because of drainage into the river. Channels taking water diverted at these anicuts have low efficiency figures. For example, because of a large amount of drainage into the river, the Kodagan Channel showed only a 17 percent efficiency.

Most important, the daily demand for each channel is set by its laskars without regard for demands from other channels. To serve their farmers, laskars may demand as much water as they can get. The PWD officials have no way to verify the accuracy of the demands, so they try to satisfy them insofar as possible.

The average efficiency of supply for all channels was 39 percent. The long-term average flow supplied at the channel heads is 1,074 million cubic meters, or an annual supply of 3,072 millimeters for the registered command. The average annual crop water requirement for rice is only 1,733 millimeters. Consequently, if the channels were operated at about 57 percent efficiency, it would be possible to irrigate the entire reg-

[5] This is a target figure used by the PWD engineers; it is equivalent to two seasons at the standard figure of 6 acres per million cubic feet used for allocation of water for the kar and advance kar seasons.

FIGURE 3.
Water deliveries to the channels, 1994–95. (Dark shading shows channel requirement.)



istered command with an intensity of 200 percent in a normal year. At the 1994–95 average efficiency of 39 percent, this is not possible, to say nothing of irrigating additional areas.

Main system water delivery performance. This analysis of main system water delivery performance in 1994–95 brings out the following:

- Deliveries to the channels were far short of the goal of continuous supply, including full supply when required, indicated in the operating rules.
- There were large inequities in water distribution to the different channels.
- Water delivery efficiency was rather low.

The 1994–95 hydrologic year had significantly more water than the average year. Therefore, we cannot infer that the inefficiencies and inequities found in 1994–95 are repeated every year. However, table 3 shows that at least some of the problems also occurred in 1992 and 1993.

Water distribution rules compared with water delivery performance. The poor delivery performance on the main system in Tambraparani in 1994–95 can be directly linked to deficiencies and subversion of the water distribution rules. The main system management water distribution rules call for determining daily demand for each channel, consolidating that demand, and trying to satisfy it. This system cannot lead to equity and efficiency in water delivery because:

- TNEB limits the flows in the river to 1,400 cusecs (39.6 m^3/s) under the rules, which prevents PWD officials from satisfying high levels of demand.
- Demand is defined by the laskars whose primary loyalty is to the farmers they serve. A laskar has no motivation to help make water deliveries in the whole system equitable and efficient; his primary concern is to get enough water to satisfy the farmers on his channel.
- Farmers in different parts of the system have little reason to cooperate among themselves or with the PWD officials, other than their own laskars, because they have no means to influence decisions about water deliveries in other parts of the system.
- The great influence that farmers, particularly tail farmers, exert over allocations, keeps allocations from being as closely related to water availability as they should be. When water availability is low, manipulations of allocations and deliveries by farmers and laskars can stress portions of the system.

The poor water delivery performance observed in 1994–95 is in large part a product of the deficiencies in the water distribution rules. This suggests that, even in a year with lower water availability, water delivery performance in the Tambraparani Irrigation System is likely to be poor.

In Tambraparani, there are opportunities to improve water delivery performance through better management. However, to do so would require modifying the allocation rules so that farmers have no need to pressure system managers for special releases or to take water from channels in an unplanned way, modifying the rules that allow the TNEB to prevent the PWD officials from releasing water from the reservoirs as needed, and modifying the main system management rules that allow the laskars to unilaterally define demands at the channel heads. In addition, better information on rainfall and reuse would allow modification of deliveries to the channels to make use of these sources of water. Also, better channel maintenance would increase the efficiency of delivery on the channels.

Because our data does not let us analyze water deliveries on the channels, we make no comments here about changes to the scheduling rules for the channels.

Transaction costs and the institutional environment of irrigation management

The deficiencies of the Tambraparani water distribution rules increase irrigation costs in several ways.

Increases in transaction costs. Subversion and evasion of the water distribution rules in Tambraparani raise the transaction costs of irrigation service for farmers. Currently, state irrigation charges are incorporated into land taxes.

Besides the state irrigation charges, Tambraparani farmers also bear the expense:

- of giving payments and gifts to laskars to reward them and to ensure their cooperation.
- of pressuring officials, through WUAs, to authorize irrigation allocations or special issues for their areas. This entails the cost of maintaining the WUA as well as giving gifts to the officials and covering the costs of meeting with the officials, etc.
- of carrying out demonstrations and disruptive tactics, requiring organizational effort and time and carrying the risk of punishment by the police.
- of, in extreme cases, taking their water problems to court through WUAs. This includes the time, effort, and other costs of creating and maintaining WUAs for this purpose, as well as the court costs.

Weakening government institutions. Evasion and subversion of the water distribution rules lessen the effectiveness of the PWD and weaken other government agencies connected with irrigation. The PWD officials are placed in the difficult position of either trying to follow the distribution rules or serving the farmers by subverting the rules; they cannot do both effectively. If they follow the rules, they face conflicts, insubordination, subversion, and other problems. If they serve the farmers against the rules, they can no longer justify their actions to critics, making it difficult to enforce discipline within the organization.

Farmers and officials are aware that actual water distribution is far from what it is supposed to be. Yet, to keep their jobs, PWD officials, district collectors, and other government officials try to appear to operate according to the rules. This results in incorrect reports on cultivated areas and other faulty data. This also means that the officials cannot operate in the most effective ways, resulting in a loss of respect for the government officials.

Weakening of government authority adds to the transaction costs of irrigation. If government agencies are ineffectual, farmers are forced to rely upon themselves to protect their resources and rights from depredations by others. A major reason for the large number of WUAs in the Tambraparani Irrigation System is that *WUAs are the farmers' means of protecting their rights.* Although many WUAs in Tambraparani had their origins in tank management organizations, the number of WUAs has risen greatly since the 1960s (Pundarikanthan et al. 1992) because of the increasing numbers of conflicts over water.

Loss to the government. Farmers are obviously willing to pay the higher transaction costs forced by the mismatch of rules and goals. As Repetto (1986) points out, these payments are a form of economic rent that is now being captured by officials. This observation suggests that, by changing the rules and by establishing a new system for levying irrigation fees, the state could collect these extra resources. The state is losing an opportunity to help its finances.

Losses to the Manimuthar farmers. Another consequence of the deficiencies in the distribution rules is that water that the state intended for the farmers under the Manimuthar High Level Canal is being diverted to farmers in the Tambraparani Irrigation System. We have no data to show the consequences of this diversion. Presumably, crop production is lower within the Manimuthar command than it would be if water allocated to it by the rules were delivered.

Changing the water distribution rules

Improving the situation in Tambraparani. The deficiencies in the rules have led to poor water distribution performance and have aggravated conflicts among farmers. Evasion and subversion of the rules are widespread.

Enforcing the rules, however, is not the way to improve the situation. Doing so probably would lower the value of crop production and probably is not possible, given the collusion of government officials in the subversion of the rules. The key to improving the situation lies in *changing the rules, within the bounds of technical possibilities, to remove the inconsistencies and to make the rules define patterns of delivery that better match the goals of all the users.*

Improvements are quite feasible. The total crop water requirement for bananas, over the full year, is 1,600 millimeters, whereas the total crop water requirement for two rice crops in the tail reaches is 1,953 millimeters. That is, bananas require less water than two rice crops. Thus, changing the rules to sanction delivery of water for bananas need not result in losses to rice farmers, although it might shift areas irrigated during drier parts of the year from one part of the scheme to another (Pundarikanthan et al. 1992). Further, recognizing and abetting the spread of banana cultivation in Tambraparani would make the irrigation demand more even over the year and would make irrigation requirements more compatible with power generation requirements.

Why have the rules remained unchanged? Virtually everyone involved in managing the Tambraparani Irrigation System recognizes the need for change. Interviewed PWD officials say that system operations could be adapted to irrigate bananas, thus solving one major problem. Farmers too would like the rules changed. But officials and farmers do not change the operating rules for several reasons.

First, farmers cannot initiate the change process; only the district collector or the

PWD executive engineer can initiate a change in the rules. Proposed changes have to be taken to higher levels in the PWD and other state agencies for approval. Changes to "rules of regulation" require state cabinet approval.

Second, appealing to the district collector is a standard means for the general population to initiate government action. However, for the Tambraparani Irrigation System, neither of the two district collectors will initiate changes without the consent of the other. Persuading a district collector to change the rules was much simpler in the 1960s when advance kar season was authorized, because only one collector had to be convinced.

Third, there is no constituency for change among the officials of the PWD. Some PWD officials gain from the present situation (cf. Ramamurthy 1989; Repetto 1986). Other PWD officials feel no pressure to improve system performance.

Finally, officials are slow to initiate changes because farmers differ on the desired changes. The court cases mentioned earlier show that farmers are not in full agreement over how the rules should be changed.

These factors make the change process long and difficult.

Proposed changes and the need for consultation with farmers. In 1991, the PWD commissioned the Indian Institute of Technology, Madras, to do a study of the Tambraparani Irrigation System. One objective was to recommend revised rules of regulation for the system to incorporate the Servalar Reservoir. Based on simulation studies, the institute's reports recommend changes in Tambraparani water distribution rules, including the recognition of additional cropping systems (Raman, Elango, and Mohan 1993). Their recommendations are now under consideration by the PWD.

At present, water distribution rules for irrigation in Tamil Nadu are set and reviewed by the state agencies; consultation with the users is not required and is sometimes foregone. In Tambraparani, failure to carry out sufficient consultation has led to the deficiencies in the rules. In contrast, rules for water distribution for industrial and municipal uses are set by discussions and negotiation between the state and the interested parties. This process has had good results. This contrast clearly suggests a need to consult farmers on the rules for irrigation. It also suggests that farmers and other users should have the power to initiate review of the water distribution rules. Technical studies, such as the ones by the Indian Institute of Technology, are needed to check the technical feasibility of proposed changes or to form the basis for change proposals, but they are not substitutes for direct consultation with the users.

A key reason for consultations with farmers is to get the farmers to understand and accept limitations imposed by water availability and technical problems. That is, farmers must realistically adapt their desires to the limitations of the situation. It has been shown elsewhere that once farmers understand the limitations of the system and of their own power, they are also willing to modify their expectations from the system (Brewer, Sakthivadivel, and Somaratne 1993).

Consultation on changes to the water distribution rules should include representatives of all interested persons. In the case of Tambraparani, this would mean that the farmers under the Manimuthar Reservoir command should be included in the consultations.

Tradeoffs in changing the water distribution rules. There are tradeoffs to be considered when considering changes to the Tambraparani water distribution rules. Because in present market conditions bananas are much more profitable for farmers than rice, changing the rules to serve banana cultivation will benefit farmers. The only tradeoff would occur if tail farmers' cultivation of bananas deprives head and middle areas of water for other crops. This problem can be prevented by careful rule formulation. It may be impossible to prevent when, as at present, water is allocated through subversion of the rules.

On the other hand, changing operating rules for the Papanasam and Servalar reservoirs to allow larger releases for irrigation may affect the TNEB's ability to provide electricity at times of low inflow to the reservoirs. There may be a need to weigh the value of the power against the value of the crops. Similarly, improving the Manimuthar Reservoir operating rules may require balancing the crop production and implicit rights to water of the farmers in the Manimuthar command against the crops and rights of farmers in the Tambraparani command.

The Lessons of Tambraparani

This study of the Tambraparani Irrigation System suggests several lessons. First, if the - rules to make an irrigation system serve their desires. Evasion and subversion of the water distribution rules have adverse consequences, including poor water distribution performance and higher costs for irrigators. Second, inconsistent sets of water distribution rules cause operational problems that are likely to lead to failure to obey the rules and to poor water distribution performance.

A corollary to these findings is that appropriate provisions should be made for modifying water distribution rules as problems are discovered or demands change. These provisions should include means that give the users direct input into the redesign of these rules.

Need for change

Changes in demands on irrigation systems are accelerating with population growth and development. Population growth is a major source of change and generally leads to demands for more irrigated farmland, for more water for municipal and domestic needs, and for water for industrial development. Increasing crop diversification also places additional demands on irrigation system management. Such changes are common in all developing countries.

Responding effectively to these changes requires altering the institutional resources used for managing irrigation systems, including the formal water distribution rules. As pointed out by Templer (1984, 43):

> Natural resource managers and planners sometimes overlook the significance of this invisible institutional framework, despite the fact that it can serve as an absolute constraint on the way in which water and related land are used. Once established in the law by court decision, statute, or customary practice, water law systems resist change and are often difficult to replace or modernize to keep pace with changing water demands or social concerns. As competition for limited water supplies increases, these slowly evolving institutions can have a significant impact on opportunities for efficient water use and management . . . .

Adapting water distribution rules to changing demands

How can the responsible persons and agencies ensure that water distribution rules are consistent and adapted to the technically feasible goals of the users? One part of the answer lies in developing a concern for the consequences of the present rules and management practices. System managers should not only be concerned with ensuring that the rules are being followed, they should also be concerned with whether they are achieving the expected overall ends (Murray-Rust and Snellen 1993; Bos et al. 1994). If system managers periodically examine the latter aspect, they will be forced to face the changing demands of the users. We recommend that system managers, together with user representatives, formally review system performance annually (cf. Frederiksen 1992).

The second part of the answer lies in providing effective "voice" to farmers and other users. It is in the interest of users to remove inconsistencies and to adapt the distribution rules to their goals. If farmers and other users have direct influence over system management, they are likely to force needed changes. When demands for water increase to the point that not all persons desiring water can be served, then the hard decisions about who is to get water must be made by the political authorities. Making the users part of the process will make these hard decisions more politically acceptable. Of course, water distribution rules must be adapted to technical realities, as well as to the goals of the users.

The change process must not be so quick and easy that water distribution rules are changed often or without good reason. Rapid changes negate the main advantages of water distribution rules—predictability and ease of decision making. Balance is required between providing ways to change the rules and making changes sufficiently difficult so that only necessary changes are made. Requiring effective consultation with the users will help provide this balance.

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